Canada's Nuclear Regulator

CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2011

INFO-0836

September 2012

Canadian Nuclear Safety Commission
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Canada

CNSC staff integrated safety assessment of Canadian nuclear power plants for 2011

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Cover images: Canadian Nuclear Power Plants

From left to right:
Darlington Nuclear Generating Station (Bowmanville, Ontario)
Gentilly-2 Nuclear Generating Station (Becancour, Quebec)
Point Lepreau Nuclear Generating Station (Point Lepreau, New Brunswick)
Bruce A and Bruce B Nuclear Generating Stations (Tiverton, Ontario)
Pickering A and Pickering B Nuclear Generating Stations (Pickering, Ontario)

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Executive Summary

Each year, the Canadian Nuclear Safety Commission (CNSC) publishes a report on the safety performance of Canada's nuclear power plants (NPPs). This report, entitled *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2011* (commonly referred to as the "NPP Report"), summarizes CNSC staff's assessment of the Canadian nuclear power industry's safety performance during 2011. As part of the assessment, CNSC staff evaluated how well licensees are meeting regulatory requirements and expectations for the performance of programs in 14 safety and control areas (SCAs). The report makes comparisons and shows trends, where possible, and it highlights emerging regulatory issues pertaining to the industry at large and to each licensed station.

The report consists of three major parts:

- Part 1 provides the assessment of the safety performance for the nuclear power industry as a whole and for each licensed station.
- Part 2 provides detailed information on licensing and other regulatory issues pertaining to each licensed station (it covers the period from January 2011 to April 2012, thereby permitting the most up-to-date view of issues at each of the NPPs).
- Part 3 provides information on the actions taken by the Canadian nuclear power industry in response to a CNSC request following the 2011 accident at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi NPP.

Overall performance highlights

CNSC staff concluded, based on inspections and reviews conducted during the year, that Canada's NPPs operated safely during 2011. This conclusion is based on the following observations:

- There were no serious process failures at the NPPs.
- No member of the public received a radiation dose that exceeded the regulatory limit.
- No worker at any NPP received a radiation dose that exceeded the regulatory limits.
- The frequency and severity of injuries/accidents involving workers were minimal.
- No radiological releases from the stations exceeded the regulatory limits.
- Licensees complied with their licence conditions concerning Canada's international obligations.

Furthermore, licensees complied with the regulatory request issued in response to the Fukushima Daiichi nuclear accident.

The annual NPP Report includes a rating for each SCA and provides an integrated plant rating (IPR) for each NPP, which represents the overall safety performance as measured against the relevant requirements and expectations. For the 2011 NPP Report, all 14 SCA ratings were used in determining the station and industry IPRs.

The 2011 ratings for the SCAs and the IPRs for Canada's NPPs are presented in table 1, along with the industry averages. The rating categories are "fully satisfactory" (FS), "satisfactory" (SA), "below expectations" (BE) and "unacceptable" (UA).

Table 1: Canadian nuclear power plant safety performance ratings for 2011

Safety and control area	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Management system	SA	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	FS	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	FS	SA	SA	SA	SA	SA
Radiation protection	SA	SA	FS	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA	SA	SA	SA
Security	FS	FS	SA	SA	SA	SA	SA	SA
Safeguards	SA	SA	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	SA	SA	FS	SA	SA	SA	SA	SA

The integrated plant ratings in 2011 were "fully satisfactory" for Darlington and "satisfactory" for all other stations. This is unchanged from the ratings presented in the 2010 NPP Report.

All SCA ratings for the stations ranged from "satisfactory" to "fully satisfactory" in 2011. This is an improvement from 2010 when two SCAs were rated "below expectations" (radiation protection for Bruce A, and emergency management and fire protection for Point Lepreau). The ratings for these two particular SCAs improved to "satisfactory" in 2011.

Performance highlights of each NPP

Bruce A and B

The 2011 integrated plant ratings for Bruce A and B were both "satisfactory," unchanged from 2010.

CNSC staff noted that the safety performance in two areas was "fully satisfactory": (i) conventional health and safety, and (ii) security. All other SCA ratings were "satisfactory". The radiation protection program at Bruce A improved from "below expectations" as a result of follow-up actions for the alpha contamination incident that occurred in 2010.

Darlington
The 2011 integrated plant rating for Darlington was "fully satisfactory", unchanged from 2010.

CNSC staff noted that the safety performance in the following four areas was "fully satisfactory": (i) operating performance, (ii) fitness for service, (iii) radiation protection, and (iv) conventional health and safety. All other SCA ratings were "satisfactory".

Pickering A and B
The Pickering A and B integrated plant ratings in 2011 were both "satisfactory", unchanged from 2010.

CNSC staff noted that all SCA ratings were "satisfactory". However, while human performance management was rated as "satisfactory", CNSC staff identified problems with certification examinations, which Ontario Power Generation (OPG) is working to resolve.

In 2010, OPG announced it would not pursue refurbishment of the Pickering B units but would operate Pickering A and B for a final decade (until 2020). To support this decision, OPG has submitted a continued operations plan to ensure safe and reliable operation of these units.

Gentilly-2
The 2011 integrated plant rating for Gentilly-2 was "satisfactory", unchanged from 2010.

CNSC staff noted that all SCA ratings were "satisfactory" and that Gentilly-2 has improved its notification and activation processes for the emergency response team during the year.

The Commission Tribunal renewed the licence to Hydro-Québec for the operation of the Gentilly-2 station, with an expiry date of June 30, 2016. The operating licence contains regulatory hold points that were put in place to ensure certain inspections and work were performed. Following a successful planned outage, these hold points were lifted, and the CNSC designated officer authorized Hydro-Québec to restart the plant.

Point Lepreau
The integrated plant rating in 2011 for Point Lepreau was "satisfactory", unchanged from 2010.

CNSC staff noted that all SCA ratings were "satisfactory". Emergency management and fire protection improved from "below expectations" in 2010 as a result of improvements in the fire response performance.

The Commission Tribunal renewed the licence to NB Power for the operation of the Point Lepreau station, with an expiration date of June 30, 2017. The relicensing decision requires that NB Power perform a site-specific seismic hazard assessment and share the results of this assessment as part of its public information program.

Refurbishment activities are completed. Commissioning activities are in progress and the reactor is scheduled to return to service in the fall of 2012.

Actions resulting from the 2011 Fukushima Daiichi nuclear accident

In response to the Fukushima Daiichi nuclear accident, the CNSC directed NPP licensees in Canada to review the lessons learned and re-examine the safety cases of NPPs to ensure that sufficient defence-in-depth margins are available, with a focus on:

- external hazards such as seismic, flooding, fire and extreme weather events
- measures for prevention and mitigation of severe accidents
- emergency preparedness

The CNSC Task Force reviewed the industry responses and concluded that Canadian NPPs continue to be safe and that the risk posed to the health and safety of Canadians or to the environment remains low. The Task Force further verified that all Canadian NPPs are located far from tectonic plate boundaries and that the threat of a major earthquake at Canadian NPPs is negligible.

The Task Force raised 36 action items applicable to NPPs that the licensees will address by December 2015. When implemented, these actions will further enhance the safety of nuclear power in Canada and will reduce the associated risk to as low as reasonably practicable.

Overview

Each year, the CNSC publishes a report to summarize the CNSC staff's assessment of the safety performance of the Canadian nuclear power industry. This assessment is aligned with the legal requirements of the *Nuclear Safety and Control Act* (NSCA) and its associated regulations, the conditions of operating licences, and applicable standards and regulatory documents. Licensees are required to implement programs that make adequate provisions for the protection of the environment, the health and safety of persons, the maintenance of national security and the measures needed to implement Canada's international obligations. In short, licensees are primarily responsible for operating their plants safely.

2011 NPP Report

The *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2011* (commonly referred to as the 2011 NPP Report) assesses the safety performance of the nuclear power industry as a whole, as well as the performance of each NPP. The evaluations in this report are supported by information obtained through CNSC staff inspections, site-surveillance activities, document assessments, desktop reviews, event reviews and performance indicator data. The report makes comparisons and shows trends, where possible, and it also highlights emerging regulatory issues pertaining to the industry at large and to each licensed station.

The report consists of three distinct parts:

- Part 1 covers the 2011 calendar year. Part 1 is further divided into section 1A, "Industry performance and developments" and section 1B, "Station performance". Where pertinent, significant issues that affect the safety performance ratings in part 1 are outlined in greater detail in part 2.
- Part 2 is entitled "Regulatory developments and issues" and provides detailed information on licensing and other regulatory issues. It covers the extended period from January 2011 to April 2012, allowing CNSC staff to keep Commission Tribunal members and the public informed of more recent developments on regulatory issues.
- Part 3 provides information on the actions taken by the Canadian nuclear power industry in response to a CNSC request following the 2011 Fukushima Daiichi nuclear accident.

The 2011 NPP Report includes six appendices:

- Appendix A lists the specific safety and control areas (SCAs) along with the definitions and the performance objectives of each one.
- Appendix B provides the definitions of the rating categories for the SCAs and integrated plant ratings ("fully satisfactory", "satisfactory", etc.), as well as an explanation of the rating methodology.

- Appendix C provides research and development efforts in support of NPP regulation, including status updates for the generic action items (GAIs) and the CANDU safety issues (CSIs) that remained open in 2011.
- Appendix D provides worker doses at all Canadian NPPs in 2011, in addition to the five-year trend of annual collective effective doses to workers at each NPP.
- Appendix E contains the derived release limits for radionuclides emitted to the air or water for all Canadian NPPs.
- Appendix F provides the status of action items applicable to NPPs in response to the Fukushima Daiichi nuclear accident.

The 2011 NPP Report concludes with a reference section for acronyms and abbreviations, a glossary and references.

It is important to note that the CNSC continues to improve its operations and business practices supporting its regulatory functions. For the 2011 NPP Report, the contents and format have been revised as follows:

- Format
  Pickering A and B assessments have been grouped together for this report because the operator, Ontario Power Generation (OPG), uses common programs at both stations. This change aligns the presentations and provides a common format for the evaluations of the two licensees. Note, however, that while the text in parts 1B and 2 for Pickering A and B has been integrated, the ratings for Pickering A and Pickering B have been conducted independently and are presented separately.

- Actions resulting from the Fukushima Daiichi nuclear accident
  A new part 3 has been added to the 2011 NPP Report to include information on the response to lessons learned from the Japanese earthquake and tsunami of March 2011 that affected TEPCO's Fukushima nuclear generating station. Included in part 3 is the introduction of the 36 action items (AIs) resulting from the Fukushima Daiichi nuclear accident which licensees in Canada are undertaking to further reduce risk and improve safety of their NPPs.

  CNSC staff will be providing an additional update to the Commission Tribunal on the status of the NPP action items, as of July 31, 2012, in a supplemental Commission member document (CMD) for the August 15, 2012, public meeting.

- Safety and control areas
  The new safety and control area (SCA) framework was introduced in 2010 for use in all operating licences. It provides a common set of safety and control terms that apply across all facilities regulated by the CNSC. In last year's report (2010 NPP Report), all 14 SCAs were reported but only 10 were included in determining the integrated plant rating (IPR). For the 2011 NPP Report, all 14 SCAs have been included in determining the IPR.

- Fire protection and response
  All information related to "fire response" has been included in the specific area of "fire protection and response" in the "emergency management and fire protection" SCA, while information related to "fire protection design" has been moved to the "physical design" SCA.

- Rating for the security SCA
  In annual NPP reports since 2003, the entire security SCA was prescribed and was addressed in a separate report presented to the Commission Tribunal[1] in a non-public portion of a meeting. The security ratings and information supporting the ratings for the industry and the stations have been integrated into the 2011 NPP Report.

Canada's nuclear power plants

There are seven licensed nuclear power plants (NPPs) in Canada: Bruce A, Bruce B, Darlington, Pickering A, Pickering B, Gentilly-2 and Point Lepreau. They are located at five sites in three provinces, as shown in figure 1, and are operated by four separate licensees. These NPP sites range in size from one to four power reactors, all of which are of the CANDU (CANada Deuterium-Uranium) design. This design was developed by the Canadian crown corporation Atomic Energy of Canada Limited (AECL).

SNC-Lavalin Inc., through its wholly-owned subsidiary Candu Energy Inc., acquired AECL's reactor division in 2011. Candu Energy provides a full range of services and products to the nuclear power industry for the operation, maintenance and refurbishment of existing stations as well as the design and delivery of new CANDU reactors.

Figure 1 also provides plant data for each of the NPPs, including the generating capacity of the reactors at each site, their initial start-up dates, the names of the licensees, and the expiry dates of the operating licences. It can be seen that:

- 17 reactor units were operational in 2011
- Pickering A Units 2 and 3 were in safe storage; they were defuelled in 2008, and will remain in long-term safe storage until the eventual decommissioning of the Pickering site
- Bruce A Units 1 and 2 and Point Lepreau were not operational in 2011, as they were undergoing refurbishment for life extension

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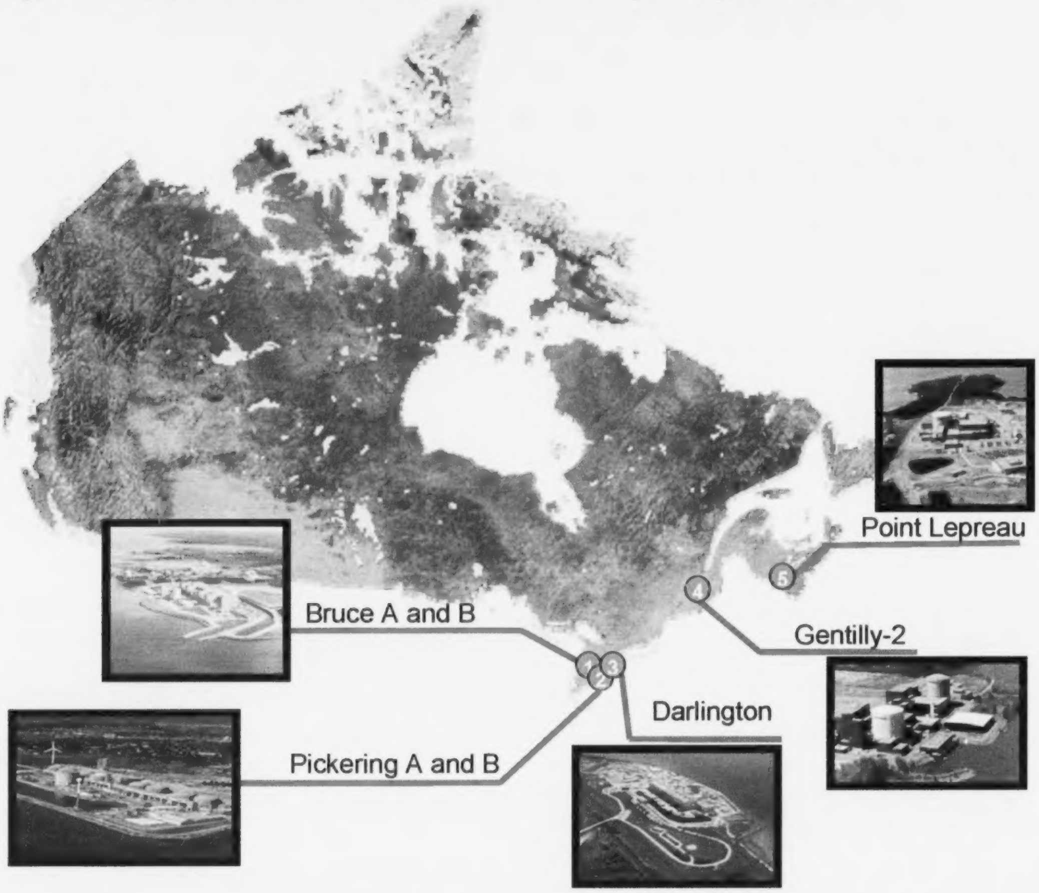
[1] Canadian Nuclear Safety Commission, or CNSC, refers to the total organization. The Commission Tribunal component, sometimes referred to as the Commission, is referred to as the Commission Tribunal in this report to distinguish it from the CNSC as a whole.

Figure 1: Locations and data for Canadian nuclear power plants in 2011



NPP	Licensee	Location	State of reactor units	Gross capacity per unit (MWe)	Start-up*	Licence expiry
Bruce A	Bruce Power Inc.	Tiverton, ON	2 operating 2 under refurbishment	904	1977	2014/10/31
Bruce B	Bruce Power Inc.	Tiverton, ON	4 operating	915	1984	2014/10/31
Darlington	Ontario Power Generation Inc.	Darlington, ON	4 operating	935	1990	2013/02/28
Pickering A	Ontario Power Generation Inc.	Pickering, ON	2 operating 2 defuelled and in safe storage	542	1971	2013/06/30
Pickering B	Ontario Power Generation Inc.	Pickering, ON	4 operating	540	1982	2013/06/30
Gentilly-2	Hydro-Québec	Bécancour, QC	1 operating	675	1983	2016/06/30
Point Lepreau	New Brunswick Power Nuclear Corp.	Lepreau, NB	1 under refurbishment	680	1982	2017/06/30

* For the multi-unit NPPs, this indicates the start-up of the first reactor unit.

Regulatory oversight

As Canada's nuclear regulator, the CNSC is responsible for regulating the operation of NPPs by issuing licences and ensuring compliance with these licences through verification, enforcement and reporting. The CNSC conducts many inspections, assessments, reviews and evaluations of licensee programs, processes and safety performance throughout the year. This work varies in complexity and length, and the implementation of the Power Reactor Regulatory Program involves the direct efforts of 229 CNSC staff, plus support from other members of the organization. This total effort includes 41 CNSC employees permanently located at the seven stations who perform onsite inspections, monitor safety performance and provide regulatory support.

Compliance verification program

The compliance verification program includes all of the compliance activities conducted by CNSC staff to determine whether licensees are complying with the regulatory requirements specified in the *Nuclear Safety and Control Act* (NSCA), the regulations made in accordance with the NSCA, and the operating licences issued by the CNSC. Compliance with these requirements ensures that the risk to the health and security of Canadians remains acceptably low.

The compliance verification program is risk-informed, performance-based and aligned with the 14 SCAs. The compliance activities which make up this program can be divided into the three following basic categories:

- surveillance
- inspections
- desktop reviews (including documentation reviews)

Surveillance includes the compliance verification activities carried out by onsite CNSC inspectors to monitor station operation and to continually verify that the licensee is operating the station safely according to CNSC requirements and expectations. Surveillance includes daily reviews of licensee databases covering operational activities (e.g., operational logs or station condition reports), observation of licensee meetings, and observations noted during field visits that are not part of another systematic inspection.

Inspections are systematic and fully documented compliance activities to determine, through objective evidence, if a licensee's program, process or practice complies with the CNSC's regulatory requirements. These inspections may be planned or reactive, announced or unannounced, or conducted by one inspector or a team. The inspections are primarily carried out by the onsite CNSC inspectors with technical support from the Ottawa-based CNSC specialist staff, who are often members of the inspection teams. CNSC staff conducted a total of 161 inspections at NPPs during 2011.

Desktop reviews are compliance activities limited to the review of documents and reports submitted by licensees. This includes quarterly technical reports, scheduled compliance reports, and unscheduled reports such as event reports and corrective action reports. The

CNSC's reporting requirements related to content, format and timing are documented in CNSC regulations, in regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and in other specific licence conditions. The majority of desktop reviews are conducted by CNSC specialist staff with support from the CNSC onsite inspectors as required. CNSC staff review the data as reported by licensees to detect potential non-compliance issues and verify the quality and completeness of the reports.

The type of compliance activity chosen to verify licensee compliance with a specific regulatory requirement is based on its effectiveness. The scope of the selected compliance activity is adjusted to minimize duplication and overlap with other compliance activities conducted on related topics. The frequency of the selected compliance activity is based on the relative risk associated with the SCA or as determined through the results of previously conducted compliance activities that provide performance insight. Other issues, such as modifications to licensee programs or changes in regulatory requirements, also have an impact. Accordingly, the compliance verification program is reviewed annually to ensure the regulatory compliance oversight focuses primarily on the appropriate SCAs.

Completion of any of the three types of compliance activities which form the compliance verification program may lead to regulatory follow-up or enforcement measures when a licensee's program, process or practice is found to be non-compliant with regulatory requirements. This regulatory enforcement is done using the CNSC-defined graduated approach.

Safety performance assessment

The NPP Report presents safety performance ratings for each SCA at each NPP based on relevant requirements and expectations. The ratings were determined based on the compliance verification program activities through reviews of the findings from inspections, as well as the review of desktop analyses, events and performance indicators. In generating the performance ratings, CNSC staff considered over 1,500 findings. Of this total number of findings, over 99 percent were assessed as being either of positive, negligible or low safety significance. In other words, the finding was one that had an effective, insignificant or small negative impact on the assessment of the specific area. The remaining findings either had a significant or major negative impact on the assessment of the specific areas. The findings were categorized into appropriate SCAs and assessed against a set of performance objectives and criteria that the CNSC developed for each SCA.

The assessment presented in the NPP Report includes an IPR for each NPP. The IPR is a general measure of the overall safety performance of each NPP, and is determined by combining the ratings of the individual SCAs. All 14 SCAs have been included in the determination of IPRs for each of the stations and for the industry. In previous NPP reports, certain SCA ratings had been excluded either because they were complementary elements or they were not commonly applied to all licensees' operating licences.

Part 1 – Safety Performance

Part 1 of this report presents CNSC staff's integrated assessment of the safety performance of Canadian NPPs, as well as the industry performance as a whole. As part of this assessment, CNSC staff evaluated how well licensees' programs met regulatory requirements and expectations and contributed to protect the overall health, safety and security of Canadians and the environment, in addition to meeting Canada's international commitments on the peaceful use of nuclear energy. The evaluations are based on findings made throughout the year during inspections, desktop reviews and event reviews and are categorized according to the following 14 SCAs:

- management system
- human performance management
- operating performance
- safety analysis
- physical design
- fitness for service
- radiation protection
- conventional health and safety
- environmental protection
- emergency management and fire protection
- waste management
- security
- safeguards
- packaging and transport

The SCA definitions and performance objectives are given in appendix A, "Definitions of Safety and Control Areas". The definitions of the performance ratings and the rating methodology used in this report can be found in appendix B, "Rating Methodology and Definitions".

1A – Industry performance and developments

This section presents the overall safety performance of the industry in each of the SCAs and highlights generic issues and observations. The overall performance of the industry is determined by calculating an "industry average" rating for each SCA.

CNSC and World Association of Nuclear Operators (WANO) performance indicators (PIs) are included in this section to illustrate various trends. CNSC PIs are defined in regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1]. It should be noted that comparing NPP data in any particular year is difficult because many factors – such as the number of operating units, design, unit capacity, or NPP governing documents – contribute to differences in PI data.

1A.1 Management system

Safety and control area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry average**
	A	**B**		**A**	**B**			
Management system	SA	SA	SA	SA	SA	SA	SA	SA

The management system SCA covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against those objectives, and fosters a healthy safety culture. The industry average for management system was "satisfactory", unchanged from the previous year.

Management system encompasses the following specific areas: management system, organization and change management, internal communication, management performance and safety culture.

Management system

For the safe operation of the nuclear facilities, Canadian NPP licensees have established at each station a management system which adheres to the requirements stated in Canadian Standards Association (CSA) standard N286-05, *Management system requirements for nuclear power plants* [2]. Through ongoing oversight activities, CNSC staff monitor the licensees' implementation of these management systems. CNSC staff did not identify any deficiencies within the industry's implementation of these management systems.

Organization and change management

The organization structure established at each NPP is documented as part of its management system documentation. The organization's documentation also includes the roles and responsibilities for certain identified positions. During the reporting period, CNSC staff did not identify any deficiencies in this area.

Internal communications
There were no significant observations from compliance verification activities to report in this specific area for 2011.

Management performance
Through various ongoing oversight activities, such as the review of periodic reports and event reports submitted in accordance with CNSC regulatory document S-99 [1], and baseline compliance inspections, CNSC staff obtained information regarding management performance within the industry. Based on the information assessed and any conducted inspections, CNSC staff concluded that management performance for the industry was effective.

Safety culture
CNSC staff participated in discussions with industry representatives regarding continuous improvement of safety performance within licensee organizations. These ongoing discussions were aimed at helping licensees improve their capacity to foster a healthy safety culture. CNSC staff did not identify any deficiencies in safety culture during the reporting period.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the management systems at NPPs met regulatory requirements.

1A.2 Human performance management

Safety and Control Area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry Average**
	A	**B**		**A**	**B**			
Human performance management	SA	SA	SA	SA	SA	SA	SA	SA

The human performance management SCA covers activities that enable effective human performance through the development and implementation of processes that ensure that licensees have sufficient staff in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties. The industry average rating for human performance management was "satisfactory", unchanged from the previous year.

Human performance management encompasses the following specific areas: personnel training, personnel certification, certification examination and requalification testing, work organization and job design, human performance programs, procedures and job aids, and fitness for duty.

Personnel training
There were no significant observations from compliance verification activities to report in this specific area for 2011.

Personnel certification

In 2011, CNSC issued a total of 59 certifications to licensees' staff and proposed not to issue three certifications. In accordance with the relevant regulations, both the licensees and the applicants were provided with an opportunity to be heard and the matter remained ongoing by the end of the reporting period.

The industry continued to maintain a sufficient contingent of certified personnel in 2011, including reactor operators (ROs), unit 0 operators (U0Os), control room shift supervisors (CRSSs), plant shift supervisors (PSSs) and senior health physicists (SHPs). Details can be seen in table 2.

Table 2: Number of valid certifications and certified positions per station

Station		**RO**	**U0O**	**CRSS/PSS**	**Subtotal (less SHPs)**	**SHP**	**Total (actual)**
Bruce A	Minimum	15	10	10	35	5	94
	Actual	37	25	27	89		
Bruce B	Minimum	30	10	10	50	4	108
	Actual	55	20	29	104		
Darlington	Minimum	30	10	10	50	2	117
	Actual	56	22	37	115		
Pickering A	Minimum	20		10	30	3	67
	Actual	46		18	64		
Pickering B	Minimum	30		10	40	3	74
	Actual	54		17	71		
Gentilly-2	Minimum	6		6	12	4	30
	Actual	13		13	26		
Point Lepreau	Minimum	6		6	12	3	24
	Actual	13		8	21		

Notes:

(i) There are no U0O positions at Pickering A, Pickering B, Gentilly-2 and Point Lepreau stations – the corresponding cells were therefore left empty and shaded in dark grey.

(ii) The SHP position is not subject to a minimum shift complement requirement – the corresponding column was therefore not assigned a minimum quantity.

Each licensee employs a number of certified persons in excess of the minimum complement set by its operating licence. Additionally, although a minimum shift complement (MSC) is not prescribed for the SHP position, the number of certified SHPs employed at each NPP was deemed sufficient to ensure personnel and public safety. During the reporting period, CNSC staff did not identify any deficiencies in this area.

Certification examination and requalification testing

In 2011, NPP shift personnel underwent a total of 119 written and oral knowledge-based initial certification examinations, 36 in-simulator performance-based initial certification examinations, and 169 requalification tests, all of which were administered by the licensees. The candidate pass rates were 90 percent for the initial certification examinations and 96 percent for the requalification tests. In addition, the CNSC administered two initial certification examinations and one requalification test to SHP candidates, who achieved an overall pass rate of 100 percent.

In accordance with the baseline compliance verification strategy, CNSC staff assured licensee compliance with CNSC requirements by leading various verification activities, including inspections covering both initial examinations and requalification tests. Based on these verification activities, CNSC staff concluded that persons recommended for certification are competent to perform their duties.

Work organization and job design

Paragraph 12(1)(*a*) of the *General Nuclear Safety and Control Regulations* (GNSCR) requires licensees to "ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely". To meet this requirement, licensees have a minimum shift complement (MSC), which is defined in regulatory guide G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement* [3], as the "minimum number of qualified workers who must be present at all times to ensure the safe operation of the nuclear facility and to ensure adequate emergency response capability."

The number and qualifications of staff necessary to meet the requirements of GNSCR 12(1)(*a*) is specific to each NPP. The MSC is determined by a systematic analysis and validation exercise which becomes part of the licensing basis for each NPP. In 2011, all licensees were requested to re-examine their MSC by using G-323 [3] to ensure the licensing basis remains valid. CNSC staff are currently reviewing MSC submissions from licensees.

Human performance programs

There were no significant observations from compliance verification activities to report in this specific area for 2011.

Procedures and job aids

There were no significant observations from compliance verification activities to report in this specific area for 2011.

Fitness for duty

In 2011, a third-party review of licensees' fitness for duty (FFD) documentation against International Atomic Energy Agency (IAEA) and Canadian industry best practices was conducted. The review identified that licensees have various methods for assessing FFD, ranging from medical examinations to supervisory observation programs, but the provisions differ significantly between licensees. CNSC staff did not identify any deficiencies in this area for the industry.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the human performance programs at NPPs met regulatory requirements.

1A.3 Operating performance

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Operating performance	SA	SA	FS	SA	SA	SA	SA	SA

The operating performance SCA includes an overall review of the conduct of the licensed activities and the activities that enable effective performance. The industry average rating for operating performance was "satisfactory" in 2011, unchanged from the previous year. One station, Darlington, was rated "fully satisfactory", also unchanged from the previous year.

Operating performance encompasses the following specific areas: conduct of licensed activities, outage management performance, adequacy of procedures, operating experience, and reporting and trending.

Conduct of licensed activities

There were no serious process failures at Canadian NPPs during 2011.

The "number of unplanned transients" performance indicator (PI) denotes the unplanned reactor power transients due to all causes while the reactor was operating and not in a guaranteed shutdown state. Unexpected power reductions may indicate problems within the plant and place unnecessary strain on systems.

Table 3 shows the number of power reductions from actuation of the shutdown, stepback or setback systems. All transients were controlled properly and power reduction was automatically initiated by the reactor control systems. The majority of the unplanned transients experienced by industry NPPs were setbacks, which are gradual power changes and pose little increased risk to plant operations. In 2011, the industry average was one reactor trip per 13,300 hours (calculation based on 17 operating units). The international performance target, as established by WANO, is less than one reactor trip per 7,000 hours of operation. It follows that in 2011, Canadian NPPs performed better than the international target by nearly doubling the average time between reactor trips. However, Bruce A and Pickering A had reactor trip rates higher than the performance target.

Table 3: Number of unplanned transients for 2011

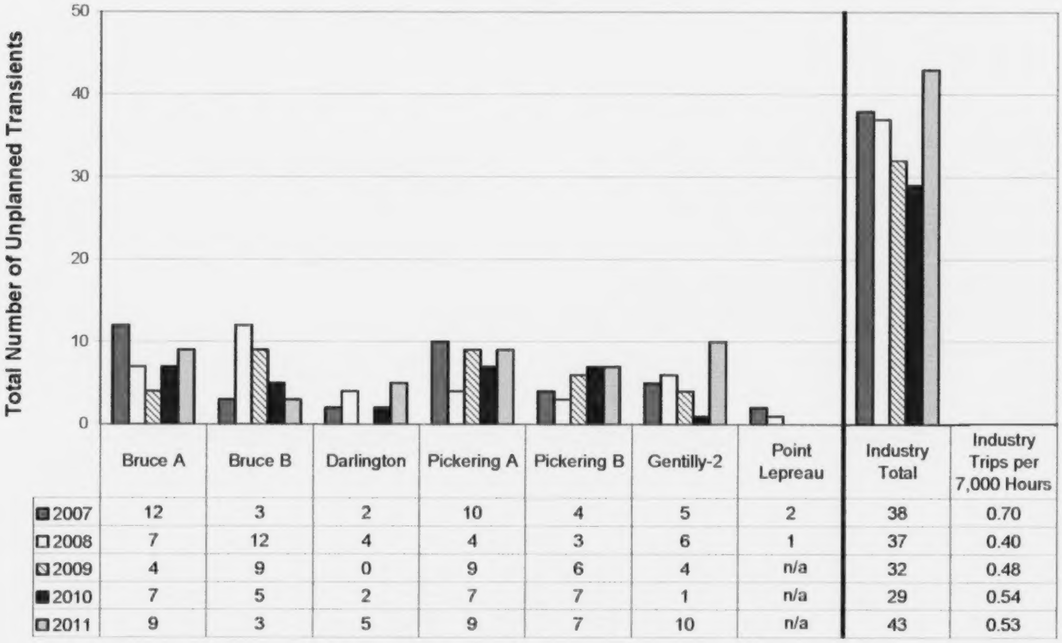
NPP	Number of hours of operation	Unplanned transients at stations in 2011				Number of trips per 7,000 operating hours**
		Trips	Stepbacks	Setbacks	Total	
Bruce A	15,817	3	0	6	9	1.33
Bruce B	33,181	0	1	2	3	0.0
Darlington	35,040	1	1	3	5	0.20
Pickering A	13,980	3	0	6	9	1.50
Pickering B	28,926	3	0	4	7	0.73
Gentilly-2	6,293	0	0	10	10	0.0
Point Lepreau*	n/a	n/a	n/a	n/a	n/a	n/a
Industry total	133,237	10	2	31	43	0.53

* Reactor in defuelled core state, due to refurbishment.

** International performance target is less than 1 reactor trip per 7,000 operating hours.

Figure 2 shows the individual station and industry trend in the number of unplanned transients from 2007 to 2011. Industry-wide, the total number of transients is higher in 2011 than in previous years due to an increase in the number of reactor power setbacks.

Figure 2: Trend details for the number of unplanned transients for stations and industry



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry Total	Industry Trips per 7,000 Hours
■ 2007	12	3	2	10	4	5	2	38	0.70
□ 2008	7	12	4	4	3	6	1	37	0.40
▨ 2009	4	9	0	9	6	4	n/a	32	0.48
■ 2010	7	5	2	7	7	1	n/a	29	0.54
□ 2011	9	3	5	9	7	10	n/a	43	0.53

Figure 3 shows the number of trips per 7,000 operating hours for the Canadian nuclear power industry in comparison to international nuclear power industry values as published by the World Association of Nuclear Operators (WANO). It can be seen that the Canadian nuclear power industry values are consistently below the international performance target level of less than one reactor trip per 7,000 hours and compare well with WANO data.

Figure 3: Trend details for the number of trips per 7,000 operating hours compared to WANO values

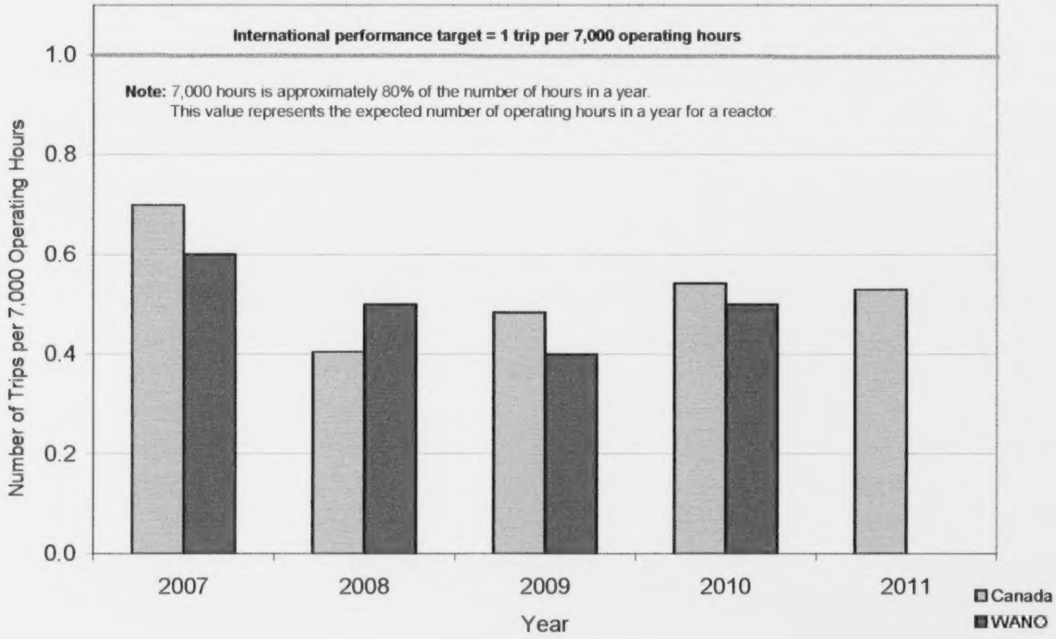
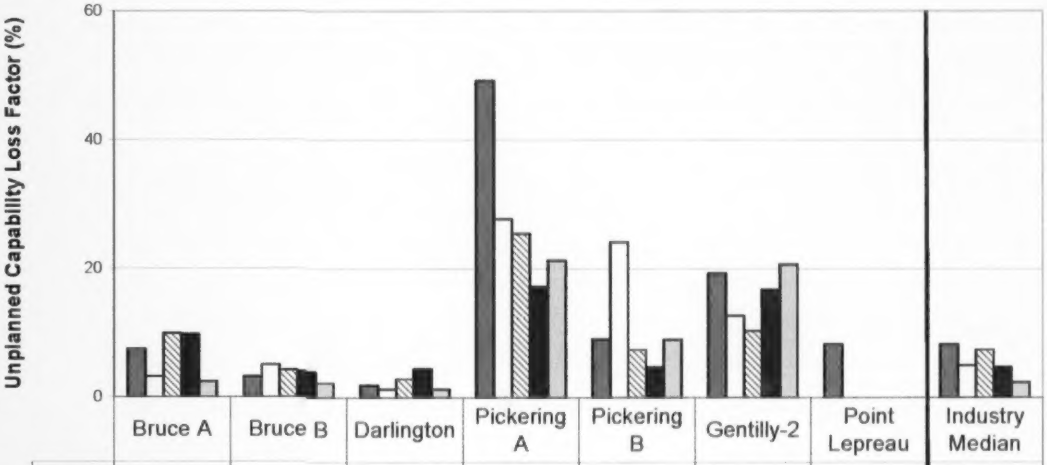


Figure 4 shows the "unplanned capability loss factor" (UCLF) PI from 2007 to 2011 for Canadian NPP licensees and the industry. The UCLF is the percentage of the reference electrical output for the station not produced during the period due to unplanned circumstances. The purpose of this PI is to indicate how a unit is managed, operated and maintained, in order to avoid forced outages. It can be seen that the UCLF PI for most individual licensees and the industry as a whole continues to remain relatively low. The industry median was 2.3 percent. However, for Pickering A and Gentilly-2, it exceeded 20 percent.

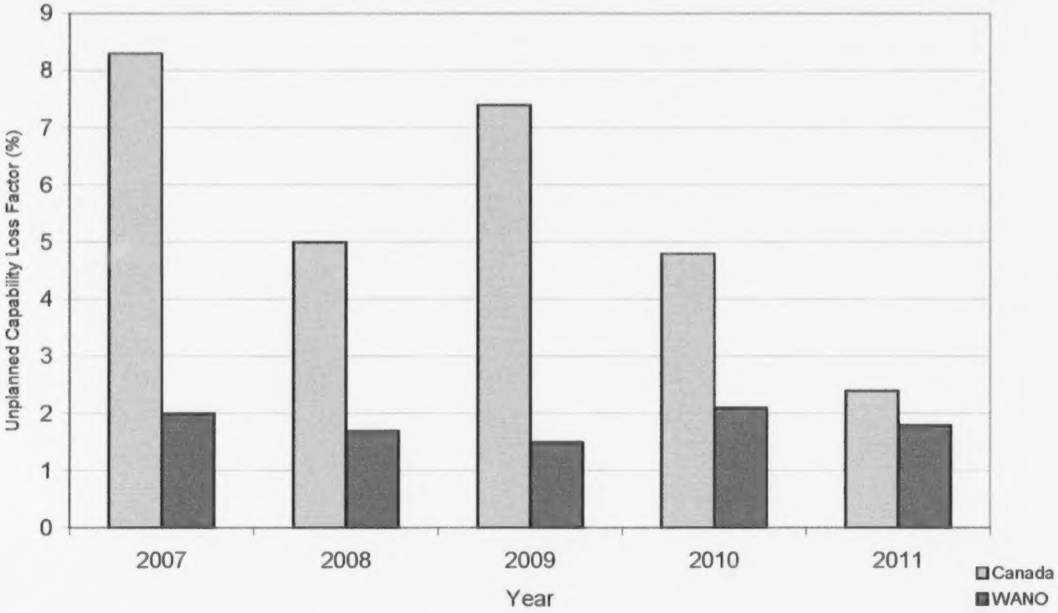
Figure 4: Trend details for unplanned capability loss factor for stations and industry



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry Median
■2007	7.5	3.2	1.9	49.2	9.1	19.3	8.3	8.3
□2008	3.2	5.0	1.3	27.7	24.1	12.7	0.0	5.0
▨2009	9.9	4.2	2.9	25.5	7.4	10.4	0.0	7.4
■2010	9.8	4.0	4.5	17.2	4.8	16.8	0.0	4.8
□2011	2.4	2.3	1.3	21.3	9.0	20.7	0.0	2.4

Figure 5 shows the UCLF for the Canadian nuclear power industry in comparison to international nuclear power industry values as published by WANO. The Canadian nuclear power industry median values are higher than the world median values. It is important to note, however, that since 2009 the industry-wide UCLF values for Canadian stations have been decreasing steadily, approaching those of the international community. The remaining variance can be explained by differences in reactor technologies, the number of reactors in each group (17 for Canada versus 434 reporting units for the WANO values) as well as station equipment maintenance and reliability, all of which have an impact on the number of forced shutdowns or outage extensions.

Figure 5: Trend of unplanned capability loss factor compared to WANO values



Based on the information assessed, CNSC staff are satisfied with the performance of NPP licensees in this area.

Outage management performance

Planned outages were managed in accordance with the operating licences and station procedures, and undertakings were conducted safely at NPPs, including refurbishment activities at the Point Lepreau NPP.

Forced outages at NPPs during the year occurred for a number of reasons, such as a release of moderator water.

In 2011, licensees met CNSC expectations for outage execution and outage safety and work management.

Adequacy of procedures

CNSC operations inspections found that licensees complied with CNSC requirements, licensee procedures and other relevant documents. The licensees also met CNSC expectations for adequacy of procedures.

Operating experience

A number of events reported to the CNSC were judged to be of public interest and therefore were reported to the Commission Tribunal as early notification reports (ENRs). Summarized information for these ENRs can be found in the station-specific sections within part 2 of this report. It should be noted that the ENRs submitted in 2011 were for events having, in general, low or no safety significance.

NPP licensees conducted appropriate follow-up actions for events including, where necessary, root-cause analyses and the implementation of corrective actions. For significant events, the industry shared the operating experience gained from their follow-up actions. These actions met CNSC expectations.

Reporting and trending

NPP licensees complied with the submission of reports as per regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1].

Overall, CNSC staff concluded that NPP licensees operated their facilities safely and in compliance with the NSCA, regulations and conditions of the licence and the licence conditions handbooks, and for Darlington, exceeded regulatory requirements.

1A.4 Safety analysis

Safety and control area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry average**
	A	**B**		**A**	**B**			
Safety analysis	SA	SA	SA	SA	SA	SA	SA	SA

The safety analysis SCA pertains to the maintenance of the safety analysis that supports the overall safety case for each facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventive measures and strategies in reducing the effects of such hazards. The industry average for safety analysis was "satisfactory" in 2011, unchanged from the previous year.

Safety analysis encompasses the following major areas: deterministic safety analysis, robustness analysis for malevolent acts, safe operating envelope (SOE), criticality safety, probabilistic safety assessment (PSA), generic action items (GAIs) and safety issues.

Deterministic safety analysis

Large loss of coolant accident

CNSC staff continue to monitor the industry's work aimed at resolving the CANDU safety issues (CSIs) related to coolant void reactivity and large loss of coolant accident (LLOCA) acceptance criteria. CNSC staff are satisfied with the industry's progress on this project which is scheduled to be completed in 2013.

Independent technical panel on shutdown system effectiveness criteria

In late 2010, CANDU Owners Group (COG) members and CNSC staff initiated a joint project to establish criteria to demonstrate shutdown system effectiveness at ensuring fuel and fuel channel integrity for various design-basis events, many of which are affected by heat transport system aging. The Independent Technical Panel created to accomplish this task issued its final report in November 2011. The panel proposed new acceptance criteria for both fuel and fuel channel integrity which differ, in some aspects, from those currently in use. CNSC staff and the industry are currently reviewing the technical basis for these new criteria as well as the applicability to licensing. CNSC staff expect to have a position on the new criteria by early 2013.

Neutron overpower protection

The new neutron overpower protection (NOP) methodology is being used by OPG and Bruce Power to assess the effects of aging. CNSC staff presented an NOP methodology update for Bruce A and B to the Commission Tribunal in March 2011. The NOP methodology progress reports were reviewed by CNSC staff in 2011. Based on the partial acceptance of the new methodology, OPG and Bruce Power have affirmed that the current neutron overpower trip setpoints are adequate for the safe operation of their stations. CNSC staff will complete their review of the OPG and Bruce Power submissions by late 2012.

Safety analysis improvement program

In 2008, in response to a CNSC request to improve safety analysis practices, NPP licensees established a COG Working Group (WG) on this subject. Initially, the scope of the safety analysis improvement (SAI) program focused on code validation work, treatment of uncertainties, updates of analysis assumptions and accounting for aging effects on safety analysis. Subsequently, the work of this WG was expanded to include the implementation of RD-310, *Safety Analysis for Nuclear Power Plants* [4]. All licensees have submitted plans for SAI, and for the implementation of RD-310 [4].

The main products of this WG include a principles and guidelines (P&G) document describing new and improved safety analysis rules that are also in conformance with RD-310 [4]. CNSC staff are currently reviewing the P&G document and the pilot analyses to gain good understanding of the detailed application of the new analysis approach.

Severe accident management

To mitigate consequences of a severe accident, CNSC regulatory guide G-306, *Severe Accident Management Programs for Nuclear Reactors* [5], expects licensees to develop and implement measures to (i) prevent the escalation of a reactor accident into an event involving severe damage to the reactor core, (ii) mitigate the consequences of an accident involving severe damage to the reactor core, and (iii) achieve a safe, stable state of the reactor and plant over the long term.

Following completion of the generic severe accident management (SAM) guidelines by COG, licensees have continued to develop and implement plant-specific SAM programs. This involves activities such as the development of plant-specific SAM procedures, establishment of the organizational framework and the technical facilities for SAM organization, staffing, training, drills, and completion of design changes, as applicable.

Robustness analysis for malevolent acts

Following the events of September 11, 2001, augmented security measures were implemented at nuclear facilities to meet the requirements of the newly amended *Nuclear Security Regulations* and revised CNSC design-basis threat (DBT) analysis. None of the malevolent aircraft impact scenarios form part of the current CNSC DBT. Therefore, at the request of the CNSC, licensees also initiated detailed consequence assessment studies for extreme events such as a large commercial aircraft crash (LCAC). CNSC staff's review of the submissions identified issues with the assessments, which require resolution to ensure the adequacy of the analysis and clarify the consequences of LCAC events. Residual issues are being tracked under site-specific actions items.

In 2011, NPP licensees were provided with loading functions, developed for new builds, representing design-basis and beyond-design-basis aircraft impact loads. Licensees were requested to reassess their previous submissions regarding the consequences and mitigation of aircraft impact at their facility and demonstrate the adequacy of the analysis based on the new loading functions. CNSC staff are currently reviewing these assessments.

Safe operating envelope

CNSC staff were involved in the development of CSA N290.15-10, *Requirements for the Safe Operating Envelope of Nuclear Power Plants* [6], published in August 2010. This technology-neutral standard provides the requirements and guidance for existing CANDU plants.

Licensees are at different stages of the development and implementation of a safe operating envelope (SOE) program. OPG, Bruce Power and NB Power are completing the development of their SOE programs. Hydro-Québec started their project following the publication of the French version of CSA N290.15-10 [6], in February 2011. CNSC staff will continue to monitor the progress of SOE towards its final implementation in the licensing basis of operating NPPs.

Criticality safety
Bruce Power is the only NPP licensee required to have a criticality safety program as it has slightly enriched uranium on site. CNSC staff noted that there were no criticality events at Bruce A and B during 2011 and they are satisfied with the provisions implemented by the licensee.

Probabilistic safety assessment
All NPP licensees must conduct probabilistic safety assessments according to the CNSC's regulatory document S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [7]. Licensees are required to develop, periodically review and update their PSAs. The PSAs, their methodologies and their updates are reviewed by CNSC staff using well-accepted international guidance to ensure compliance with S-294 [7].

During 2011, licensees made considerable progress in compliance with the requirements of S-294 [7]. The subsequent PSA activities are at various stages of implementation or under review by CNSC staff. During the reporting period, CNSC staff did not identify any deficiencies in this area.

Generic action items
A generic action item (GAI) is an important, often complex safety issue that is common to more than one station. The industry continued working towards resolution of GAIs as part of an overall industry effort to address safety issues.

Four GAIs were open in 2011. Two GAIs (00G01 "Channel voiding during a LOCA" and 01G01 "Fuel management and surveillance software upgrade") are scheduled to be closed in 2012. The remaining two GAIs (95G04 "Positive void reactivity uncertainty – treatment in LLOCA analysis" and 99G02 "Replacement of reactor physics computer codes used in safety analyses of CANDU reactors") will be tracked/monitored under the CANDU safety issues (CSIs). Information on the current GAIs is provided in appendix C, "Research and Development Efforts in Support of NPP Regulation".

Due to anticipated closures of all GAIs in 2012, this will be the final year of providing information on GAIs in the NPP Report.

Safety issues
In 2007, the CNSC initiated a project to systematically reassess the status of outstanding design and analysis safety issues for CANDU reactors and to complement the ongoing work on GAIs. The identified CSIs have measures in place to maintain safety margins; however, further experiments and/or analyses were required to improve the industry's understanding of these issues and to confirm the adequacy of the safety margins. The identified safety issues were categorized according to their relative risk importance.

By the end of 2011, 13 safety issues (out of 21) remained to be reassessed, four were related to large loss of coolant accident (LLOCA), and nine were non-LLOCA-related.

The LLOCA analytical solution project execution plan was published in March 2010. This is a high-level plan in which major tasks and deadlines are identified. For non-LLOCA issues, the industry is promoting re-categorization of the remaining issues into lower risk categories based on empirical and analytical evidence. The industry and CNSC staff are developing, monitoring and coordinating the implementation of the plan for re-categorization of these issues.

CNSC staff are satisfied with the industry's progress with respect to LLOCA and non-LLOCA safety issues. Information on CSIs is provided in appendix C.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the safety analysis programs at NPPs met regulatory requirements.

1A.5 Physical design

Safety and control area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry average**
	A	**B**		**A**	**B**			
Physical design	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**

The physical design SCA relates to activities that affect the ability of SSCs to meet and maintain their design basis given new information arising over time and considering changes in the external environment. The industry average rating for physical design was "satisfactory" in 2011, unchanged from the previous year.

Physical design encompasses the following specific areas: component design, equipment qualification, system design and classification, configuration management, human factors in design, robustness design, engineering change control, and site characterization.

Component design
There were no significant observations from compliance verification activities to report in this specific area for 2011.

Equipment qualification
The purpose of an equipment qualification program is to ensure that all required structures, systems, components, equipment and barriers are capable of performing their safety-related functions when subjected to environmentally harsh conditions resulting from design-basis accidents.

Currently, environmental qualification (EQ) programs compliant with CSA N290.13-05, *Environmental Qualification of Equipment for CANDU Nuclear Power Plants* [8], have been fully implemented at all NPPs except Gentilly-2 and Bruce A Units 1 and 2. The implementation of the EQ program at Gentilly-2 is underway and actions are implemented to resolve remaining issues. Implementation of the EQ program at Bruce A Units 1 and 2 is in progress and will be completed prior to restart of both units.

Inspections at Point Lepreau and Darlington revealed no major EQ issues. These were the only two stations where EQ inspections were conducted in 2011.

It is recognized that some challenges exist with regard to EQ preservation (notably EQ steam barriers, cable condition monitoring, and EQ document issues), but it is also acknowledged that licensees are evaluating and resolving identified EQ issues to ensure the sustainability of their EQ programs throughout the life of station unit(s). Overall, the industry continued to perform effectively in the area of EQ in 2011.

System design and classification

Reactor control, process and control, instrumentation and controls including software

In 2011, instrumentation and control (I&C) ratings for licensees were based on improvements of degraded components. The industry has continued to maintain and improve the reliability of I&C systems through replacement projects and maintenance strategy.

Point Lepreau has improved the instrumentation and control area with the programmable digital comparator replacement. In addition, both Darlington and Gentilly-2 have initiated a digital control computer replacement project.

During the reporting period, all stations performed well in their area as indicated by CNSC staff inspections and review of licensee submissions.

Service water systems, including emergency service water systems

The service water systems (SWSs) supply water at low temperature to equipment. This water is principally used for cooling, but is also used for non-cooling functions such as lubricating pump bearings and retaining pump seals.

The SWSs provide water to a very large number of components and systems; however, from a nuclear safety perspective, the most important service water loads are associated with:

- the removal of a portion of the heat from the reactor core, e.g., moderator heat exchanger cooling and end-shield cooling
- cooling functions to ensure proper functioning of systems important to safety, e.g., instrument air compressors and boiler room air-cooling units

During 2011, the SWSs functioned well at all of the NPPs, and no significant safety issues were observed by CNSC staff.

Electrical distribution system

The electrical distribution system (EDS) is a support system that is critical for cooling, controlling, containing and monitoring the reactor and auxiliary systems. The EDS is designed to satisfy the high safety and reliability requirements for nuclear systems. The EDS is classified into four levels of reliability: Class I, Class II, Class III and Class IV power supply buses, listed in descending order based on their reliability. Each power supply is provided with independent and backup power sources. In addition to the above, an independent power supply system is also provided, referred to as the emergency power supply (EPS) system. The EPS system is designed to supply power during seismic events.

During 2011, the EDS functioned well at all NPPs, and no significant safety issues were observed. With respect to the operational performance of EDSs, no significant safety issues occurred. At some NPPs, however, areas for improvement were identified by CNSC staff; these are being addressed by the licensees.

Fire protection design

There were no significant reportable events during the year that had an effect on the licensees' fire protection programs or their implementation.

Darlington, Pickering A and B, and Bruce A and B have submitted their fire protection code compliance reviews, fire hazard assessments and fire safe shutdown analyses in accordance with the requirements of CSA N293-07, *Fire Protection for CANDU Nuclear Power Plants* [9]. CNSC staff are currently reviewing these submissions and this effort is expected to be completed by December 2012. The implementation of CSA N293-07 [9] is scheduled to be completed at Gentilly-2 by the end of 2012, with the updated fire protection program and analyses due by the end of March 2012. For Point Lepreau, compliance with CSA N293-07 [9] and resolution of legacy design issues are to be completed by the end of 2014.

In general, CNSC staff did not identify any deficiencies in the implementation of the fire protection programs across the industry in 2011.

Cyber security

CNSC staff observed that the industry has continued to improve cyber security by conducting self-assessments and by implementing systematic cyber security programs. CNSC staff are satisfied with the industry's progress in this area.

Configuration management

Configuration management (CM) is an important program of the physical design SCA. For NPPs, this topic includes identifying and documenting the characteristics of the SSCs (including computer systems and software) and ensuring that the changes to the characteristics are properly included in NPP documentation.

In 2011, no significant safety issues were identified in the implementation of the CM program.

Human factors in design

CNSC staff noted that, at Gentilly-2 and Point Lepreau, improvements were observed in the availability of human factors specialists and their involvement in the design process. For Bruce A and B, Darlington and Pickering A and B, there was insufficient data available for CNSC staff to comment on the specific area of human factors in design at these stations.

Robustness design
This specific area covers activities that ensure the designs of engineered systems at nuclear facilities have sufficient robustness against anticipated threats; this includes protection against a malevolent aircraft crash at a nuclear facility.

Following their construction, operating NPPs were assessed against general aviation (typically single-engine propeller-driven aircraft) scenarios. The analysis demonstrated that, for both design-basis threat and general aviation aircraft impact scenarios, all essential safety functions (reactor shutdown, fuel cooling, and containment) would be preserved.

For credible "beyond-design-basis threat" scenarios involving commercial aircraft crashes, CNSC staff expect that at least two basic safety functions would be preserved: reactor shutdown and core cooling, or reactor shutdown and containment. With respect to irradiated fuel bays, it is expected that the fuel cooling function would be preserved. These assessments are under review by CNSC staff.

Robustness design and robustness analysis for malevolent acts are closely interconnected, Further information on the performance of the industry related to malevolent aircraft crashes is provided in 1A.4, Safety Analysis, "Robustness analysis for malevolent acts".

Engineering change control
CNSC staff did not identify any industry-wide deficiencies regarding the engineering change controls being applied to safely implement changes to SSCs.

Site characterization
There were no significant observations from compliance verification activities to report in this specific area for 2011.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the physical design programs at NPPs met regulatory requirements.

1A.6 Fitness for service

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Fitness for service	SA	SA	FS	SA	SA	SA	SA	SA

The fitness for service SCA covers activities that affect the physical condition of SSCs to ensure that they remain effective over time. This includes programs that ensure all equipment is available to perform its intended design function when called upon to do so. The industry average rating for fitness for service was "satisfactory" in 2011, unchanged from the previous year. One station, Darlington, was rated "fully satisfactory", also unchanged from the previous year.

Fitness for service encompasses the following major areas: maintenance, reliability, periodic inspections, lifecycle management / aging management, and in-service inspection for balance-of-plant.

Maintenance

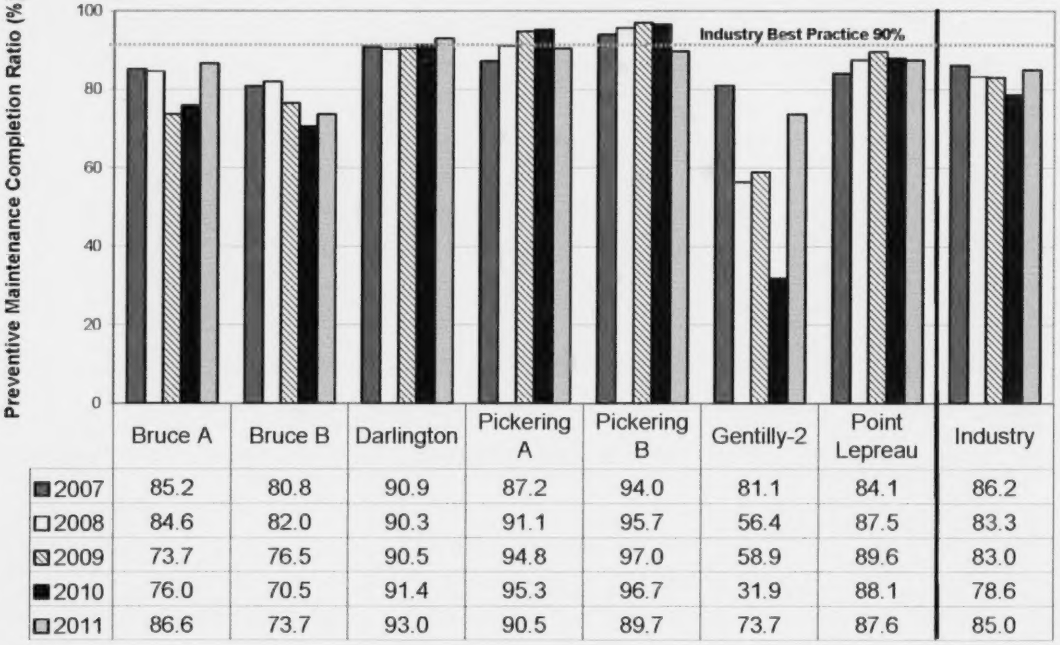
Regulatory document S-210, *Maintenance Programs for Nuclear Power Plants* [10], sets out requirements for maintenance programs, with a focus on managed processes. Compliance with the document is being introduced as a licence condition upon operating licence renewal.

Maintenance inspections carried out during 2011 did not identify any major issues. CNSC staff routinely monitor several maintenance performance indicators, including preventive maintenance completion ratio (PMCR) and maintenance backlogs. The maintenance backlogs give an indication of the plant's material condition. There will always be a certain level of backlog, due to normal operation and equipment aging. Nevertheless, CNSC staff noted that the backlog levels of maintenance improved at most sites over the 2011 operating year. However, several stations continue to have backlog levels that are higher than industry best practice, and this will remain a focus area for CNSC staff in 2012.

The PMCR performance indicator (PI) is the ratio of preventive maintenance work orders completed on safety-related equipment divided by the total maintenance work orders (preventive maintenance plus corrective maintenance) completed on safety-related equipment. The PMCR monitors the effectiveness of the preventive maintenance program in minimizing the need for corrective maintenance activities.

In 2011, the PMCR values increased for four NPPs and the industry as a whole, as seen in figure 6. This indicates an improvement with respect to completing preventive maintenance work orders. (Industry best practice sets a target of 90 percent or better for this indicator). The average PMCR values for Darlington and Pickering A were above 90 percent while the value for Pickering B was almost 90 percent. The PMCR values for Bruce A (86.6 percent) and Point Lepreau (88.1 percent) are close to the target for industry best practice, and the value for Bruce B (73.7 percent) was approaching the target. The Gentilly-2 PMCR value improved significantly during 2011, more than doubling what was reported for 2010, and continues to progress toward the target for industry best practice.

Figure 6: Trend details for preventive maintenance completion ratio for stations and industry



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry
■2007	85.2	80.8	90.9	87.2	94.0	81.1	84.1	86.2
□2008	84.6	82.0	90.3	91.1	95.7	56.4	87.5	83.3
▨2009	73.7	76.5	90.5	94.8	97.0	58.9	89.6	83.0
■2010	76.0	70.5	91.4	95.3	96.7	31.9	88.1	78.6
□2011	86.6	73.7	93.0	90.5	89.7	73.7	87.6	85.0

CNSC staff observed improvements in the preventive maintenance completion ratio for most stations and in particular for Gentilly-2 where the completion ratio improved by a significant margin of more than 40 percent.

Reliability

Licensees have reliability programs based on the requirements given by regulatory document S-98, *Reliability Programs for Nuclear Power Plants* [11], in order to ensure that systems important to safety can and will meet their defined design and performance specifications at acceptable levels of reliability, throughout the life of the facility.

The "number of missed mandatory safety system tests" PI shows the degree of completion of tests required by licence conditions. It is a measure of the licensee's ability to successfully complete routine tests on safety-related systems. Data for this PI for the stations and industry as a whole is shown in table 4 and figure 7. The recent overall trend displays a significant reduction in the number of tests missed.

It should be noted that the missed tests for the industry as a whole represent an extremely low 0.01 percent of the total mandatory safety system tests performed by licensees during the year. This represents negligible risk because a missed test is normally performed shortly after the required time. Also, the involved safety systems have sufficiently high redundancy to ensure continuous safety system availability. Three stations, Bruce B, Darlington and Gentilly-2, had no missed mandatory safety system tests in 2011.

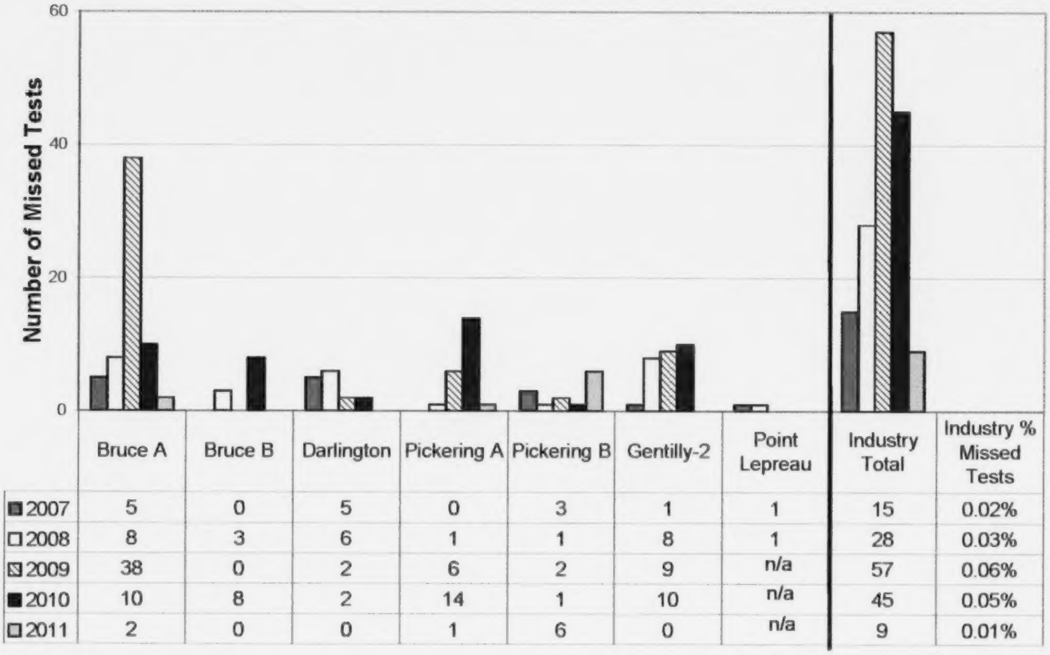
In 2011, all licensees were in compliance with the reliability requirements, as determined through inspections of systems important to safety and reviews of station reports.

Table 4: Missed mandatory safety system tests for 2011

NPP	Total number of tests	Missed mandatory safety system tests				Missed tests [%]
		Special safety systems	Standby safety systems	Safety-related process systems	Total	
Bruce A	21,713	0	1	1	2	0.01%
Bruce B	28,845	0	0	0	0	0.00%
Darlington	14,400	0	0	0	0	0.00%
Pickering A	14,648	1	0	0	1	0.01%
Pickering B	10,984	2	0	4	6	0.05%
Gentilly-2	4,341	0	0	0	0	0.00%
Point Lepreau*	n/a	n/a	n/a	n/a	n/a	n/a
Industry total	94,931	3	1	5	9	0.01%

* No tests were scheduled at Point Lepreau because the reactor was in a defuelled state.

Figure 7: Trend details of missed mandatory safety system tests for stations and industry



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry Total	Industry % Missed Tests
■ 2007	5	0	5	0	3	1	1	15	0.02%
□ 2008	8	3	6	1	1	8	1	28	0.03%
▨ 2009	38	0	2	6	2	9	n/a	57	0.06%
■ 2010	10	8	2	14	1	10	n/a	45	0.05%
□ 2011	2	0	0	1	6	0	n/a	9	0.01%

Periodic inspections

Periodic inspections and testing of CANDU NPP SSCs, such as pressure boundary components, containment components and concrete containment structures, and in-service inspection of significant balance-of-plant SSCs, are mandatory requirements through standards referenced in an operating licence.

The CSA standards that define the requirements for periodic inspection and testing of CANDU nuclear power plant components are continually revised and updated to reflect important operating experience, and licensees are typically requested to transition to the newer standards at licence renewal.

Licensees are required to implement and maintain periodic inspection and in-service inspection programs to address these areas in accordance with a series of CSA standards. The licensees' periodic inspection and in-service inspection programs are used in the management of structural integrity of SSCs, including monitoring, fitness for service assessment, mitigation and the identification of degraded components needing repair, replacement or modification. Licensees perform periodic and in-service inspections to assess the effect of service conditions on the NPP components.

Periodic inspection of plant components

OPG and Bruce Power have completed the transition to the 2005 edition of CSA standard N285.4, *Periodic inspection of CANDU nuclear power plant components* [12], from the 1994 edition. OPG's Periodic Inspection Program (PIP) documents have been accepted by CNSC staff with a commitment from the licensee to make specific revisions to the documents at the next scheduled update for the Pickering and Darlington NPPs. Bruce Power submitted its updated program documents in November 2011, and it is anticipated that CNSC staff will decide on their acceptability in 2012.

Hydro-Québec is currently transitioning to the 2005 edition of the CSA standard; however, the updated PIP documents that were submitted in 2011 will require further modification by the licensee to demonstrate that the Gentilly-2 program complies with the 2005 edition. A timeline has not been established for completion of this activity, and the licensee currently has no further inspection outages planned prior to entering a refurbishment outage. It should be noted that dispositions of inspection findings for several components remain valid for a limited time. If the start of the refurbishment outage continues to be delayed then it may be necessary for the licensee to plan an outage prior to the expiry of the current dispositions.

NB Power is continuing to work on transitioning to the 2009 edition of the CSA standard. The licensee intends to submit final versions of the PIP documents within 90 days of completion of the refurbishment outage to ensure the updated program receives regulatory acceptance and can be rolled out in time for the first planned post-refurbishment outage.

Inspections were performed of the primary heat transport system, steam generators, fuel channels, and auxiliary systems covered under the scope of N285.4 [12] and, as a result of these inspections, no findings of component degradation were identified by CNSC staff to indicate that nuclear safety had been compromised since the last inspection.

Periodic inspection of plant containment components

In general, all licensees satisfactorily performed and reported on results of periodic inspections for containment components according to CSA N285.5-08, *Periodic inspection of CANDU nuclear power plant containment components* [13], or their referenced standard and S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1].

During 2011, Bruce Power submitted the return-to-service inspection results for containment components of Unit 2. Bruce Power and OPG submitted an acceptable monitoring program for the fibre reinforced plastic spray headers for Bruce A, Bruce B, Pickering A and Pickering B, as required by CSA N285.5 [13]. OPG and NB Power are currently adopting the 2008 edition of this standard which they will have fully implemented by 2012 and 2013, respectively.

During the reporting period, CNSC staff did not identify any deficiencies in this area.

In-service examination and testing of plant concrete containment structures

In 2011, NPP licensees submitted to the CNSC for review and acceptance the revised periodic inspection and testing program documents for the concrete containment structures to meet the requirements of the 2008 edition of CSA N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* [14].

For Darlington, Pickering A and Pickering B, CNSC staff completed the detailed reviews of the revised CSA N287.7 PIPs submitted by OPG and found them acceptable. OPG also submitted the aging management plan for concrete containment structures to CNSC staff for review and acceptance. CNSC staff completed the review and found the document acceptable.

For Bruce A and Bruce B, CNSC staff completed the review of the revised CSA N287.7 PIP documents. CNSC staff are assessing Bruce Power's response to comments made on the PIP documents. In addition to the PIP documents, CNSC staff have also provided comments to Bruce Power on the visual inspection procedure for concrete structures. Bruce Power is revising its procedure to address these comments.

The PIP documents for CSA N287.7-08 [14] for Point Lepreau and Gentilly-2 are combined with the aging management programs (AMPs) for concrete containment structures. Both licensees submitted the combined AMP/PIP documents for review.

During the reporting period, CNSC staff did not identify any deficiencies in this area.

Lifecycle management / Aging management

In 2011, CNSC staff reviewed and accepted the AMP for the concrete containment structures for OPG NPPs (Darlington, Pickering A and Pickering B). CNSC staff reviewed the AMP for the Bruce A and Bruce B concrete containment structures and provided comments to the licensee.

During the reporting period, CNSC staff did not identify any deficiencies in this area.

In-service inspection for balance-of-plant

The licensing requirement for the implementation of balance-of-plant inspection programs was added to all NPP licences, except for the Darlington licence which is due for renewal in 2013.

Industry is developing a draft CSA standard to establish minimum requirements for the inspection programs which would address the balance-of-plant inspection requirements to monitor the condition of secondary side systems and components that could have an indirect effect on nuclear safety. Until the standard is implemented, CNSC staff continue to monitor balance-of-plant inspection activities via the S-99 [1] reporting process.

During the reporting period, CNSC staff did not identify any deficiencies in this area.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the fitness for service programs at NPPs met regulatory requirements and, at Darlington, exceeded regulatory requirements.

1A.7 Radiation protection

Safety and Control Area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry Average**
	A	**B**		**A**	**B**			
Radiation protection	**SA**	**SA**	**FS**	**SA**	**SA**	**SA**	**SA**	**SA**

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure that contamination and radiation doses received are monitored and controlled. The industry average rating for the radiation protection SCA was "satisfactory" in 2011, unchanged from the previous year. One station, Darlington, was rated "fully satisfactory", unchanged from the previous year.

Radiation protection encompasses the following specific areas: application of ALARA (as low as reasonably achievable) principle, personnel dosimetry, contamination control, and worker dose control. The overall objective of the radiation protection program is to ensure that radiation exposures to workers and members of the public are kept ALARA, social and economic factors taken into account.

Application of ALARA principle

All NPP licensees continued to apply measures to keep doses received by workers ALARA in 2011. Typical ALARA controls included: appropriate use of shielding and personal protective equipment, use of teledosimetry, minimization of time in radiological areas, maximizing of distances from radioactive sources, and use of mock-up training and pre-job briefings in order to increase effectiveness of work execution in the field.

Personnel dosimetry

During the reporting period, all NPP licensees had a licensed dosimetry service to measure and monitor doses received by workers.

Contamination control

All NPP licensees continued to apply measures to control radioactive contamination in their facilities during 2011. Examples of these measures include the use of a radiological zone system and contamination control areas to contain and control contamination. Furthermore, all NPPs licensees implemented a workplace monitoring program to demonstrate that the levels of contamination are controlled. There were no contamination events in 2011 that resulted in an action level exceedance.

Worker dose control

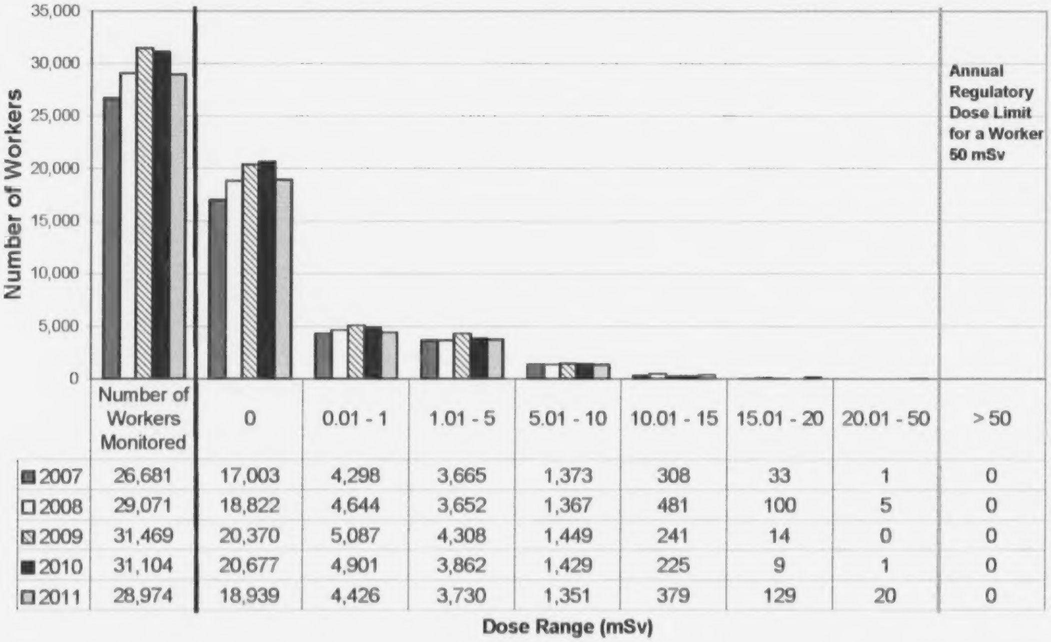
In 2011, all NPP licensees had a system in place to control radiation doses to workers. Through inspections and document reviews, CNSC staff monitored the effectiveness of the NPP licensees' radiation protection programs, including the implementation of long-term improvements related to alpha monitoring and control, and thereby ensured continued safety of workers.

The effective dose limits for nuclear energy workers, as specified in the *Radiation Protection Regulations*, is 50 milliSieverts (mSv) per year and 100 mSv over a five-year period. In 2011, there were no radiation exposures reported by any NPP that exceeded these limits.

Figure 8 provides the distribution of annual effective doses for workers at Canadian NPPs from 2007 to 2011. Analysis of figure 8 reveals the following for 2011:

- There were no radiation exposures reported at any NPP that exceeded the annual regulatory dose limits.
- Approximately 81 percent of the workers at Canadian NPPs received an annual effective dose below 1 mSv (public dose limit).
- Twenty workers received an annual effective dose greater than 20 mSv. These workers were involved in radiological work activities at Bruce A and B, including planned refurbishment activities.

Figure 8: Distribution of annual effective doses to workers in the Canadian nuclear power industry, 2007 to 2011



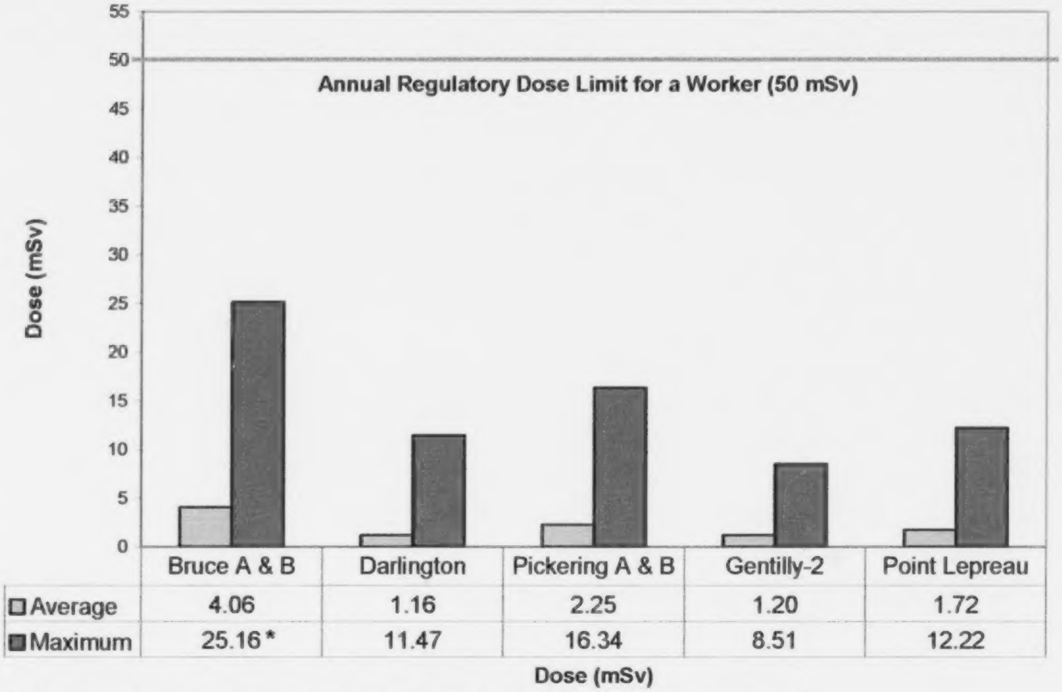
	Number of Workers Monitored	0	0.01 - 1	1.01 - 5	5.01 - 10	10.01 - 15	15.01 - 20	20.01 - 50	>50
■2007	26,681	17,003	4,298	3,665	1,373	308	33	1	0
□2008	29,071	18,822	4,644	3,652	1,367	481	100	5	0
▨2009	31,469	20,370	5,087	4,308	1,449	241	14	0	0
■2010	31,104	20,677	4,901	3,862	1,429	225	9	1	0
□2011	28,974	18,939	4,426	3,730	1,351	379	129	20	0

Figure 9 shows the arithmetic average worker effective dose based on non-zero (positive) results and the maximum effective dose to workers at Canadian NPPs for 2011. Figure 9 shows that:

- the average effective worker doses, considering non-zero results only, ranged from 1.16 to 4.06 mSv
- the highest annual effective dose received by a worker was 25.16 mSv and this represents approximately 50 percent of the regulatory dose limit for nuclear energy workers

The term "based on the non-zero dose results" in the figure 9 note indicates that the average doses are calculated by only including non-zero (positive) results in the calculation. The minimum reporting level is 0.01 mSv.

Figure 9: Average and maximum effective doses to workers in Canadian nuclear power plants for 2011



	Bruce A & B	Darlington	Pickering A & B	Gentilly-2	Point Lepreau
□ Average	4.06	1.16	2.25	1.20	1.72
■ Maximum	25.16*	11.47	16.34	8.51	12.22

Note: Arithmetic average dose values are based on the non-zero dose results only

* This maximum annual dose value was for a worker involved in radiological work activities (outages and refurbishment activities) at Bruce A and B

The annual collective dose to workers at each NPP is presented in appendix D, "2011 NPP Collective Effective Doses".

All licensees implemented and maintained an adequate radiation protection program to control the radiological hazards present in their facilities and ascertained and recorded doses for each person who performed duties in connection with their licensed activities, as required by sections 4 and 5 of the *Radiation Protection Regulations*. In addition, during 2011, all NPP licensees continued to establish and implement radiation protection program enhancements related to alpha monitoring and control that reflect CNSC expectations and industry best practices. Full implementation of the radiation protection program enhancements by all NPP licensees is planned for late 2012.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the radiation protection programs at NPPs met regulatory requirements and, at Darlington, exceeded regulatory requirements.

1A.8 Conventional health and safety

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Conventional health and safety	FS	FS	FS	SA	SA	SA	SA	SA

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment. The industry average rating for conventional health and safety was "satisfactory" in 2011, unchanged from the previous year. Three stations, namely, Bruce A and B and Darlington, were rated "fully satisfactory", also unchanged from the previous year.

Conventional health and safety encompasses the following specific areas: compliance with applicable labour codes, housekeeping/management of hazards, and accident severity/accident frequency.

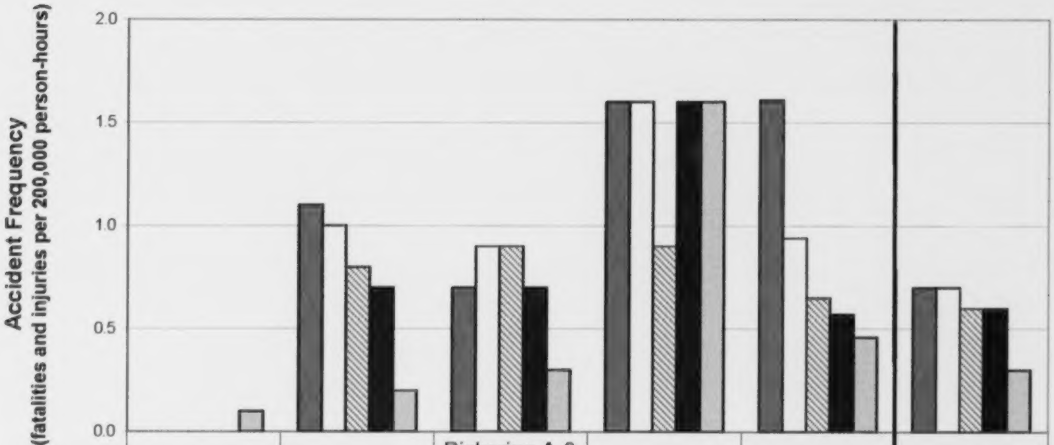
Compliance with applicable labour codes
All NPP licensees were compliant with the applicable parts of the *Canada Labour Code* and/or referenced provincial legislation during the reporting period.

Housekeeping/management of hazards
In general, most NPP licensees met CNSC requirements for housekeeping and management of hazards. However, CNSC staff identified deficiencies at Pickering A and B and these are being addressed by OPG.

Accident severity/accident frequency
Two parameters that the CNSC uses for measuring the effectiveness of the conventional health and safety program with respect to worker safety are the "accident frequency" (AF) and the "accident severity rate" (ASR) performance indicators (PIs). AF is a measure of the number of fatalities and injuries (lost-time and medically treated) due to accidents for every 200,000 person-hours (approximately 100 person-years) worked at the station. ASR is a measure of the total number of days lost due to a work-related injury for every 200,000 person-hours.

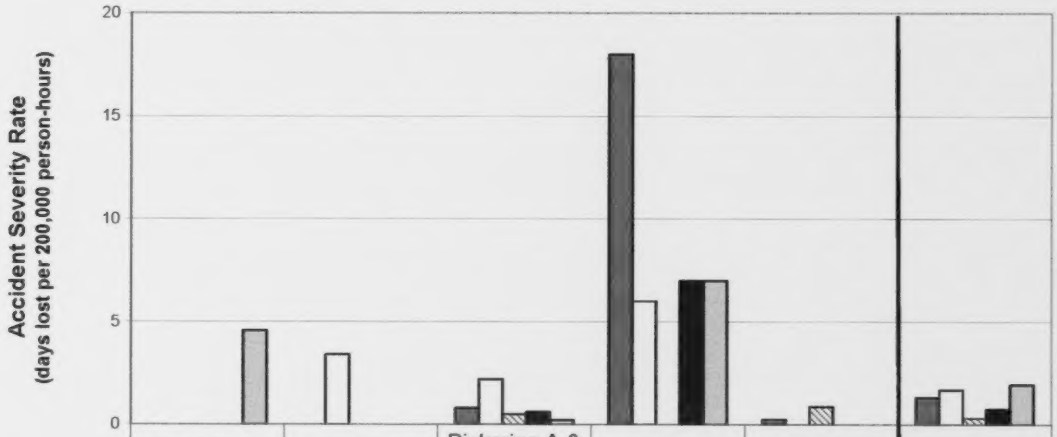
The AF and ASR PI values for the stations and the industry average are presented in figures 10 and 11, respectively. The AF values for all NPPs were very low, and for most of the NPPs and the industry as a whole the trend was downward. The industry AF values decreased from 0.6 in 2010 to 0.3 in 2011. The lowest AF value was 0.1 for Bruce A and B. The ASR value for the industry increased during 2011 primarily due to the ASR values for Bruce A and B and Gentilly-2. The ASR for the Bruce Power NPPs was due to two lost time injuries. The ASR for Gentilly-2 was mainly a result of a number of injuries that occurred during the quarter when the outage was conducted. The lowest ASR value was 0, achieved by both Darlington and Point Lepreau.

Figure 10: Trend details of accident frequency for stations and industry



	Bruce A & B	Darlington	Pickering A & B	Gentilly-2	Point Lepreau	Industry
■ 2007	0.0	1.1	0.7	1.6	1.6	0.7
□ 2008	0.0	1.0	0.9	1.6	0.9	0.7
▨ 2009	0.0	0.8	0.9	0.9	0.7	0.6
■ 2010	0.0	0.7	0.7	1.6	0.6	0.6
▒ 2011	0.1	0.2	0.3	1.6	0.5	0.3

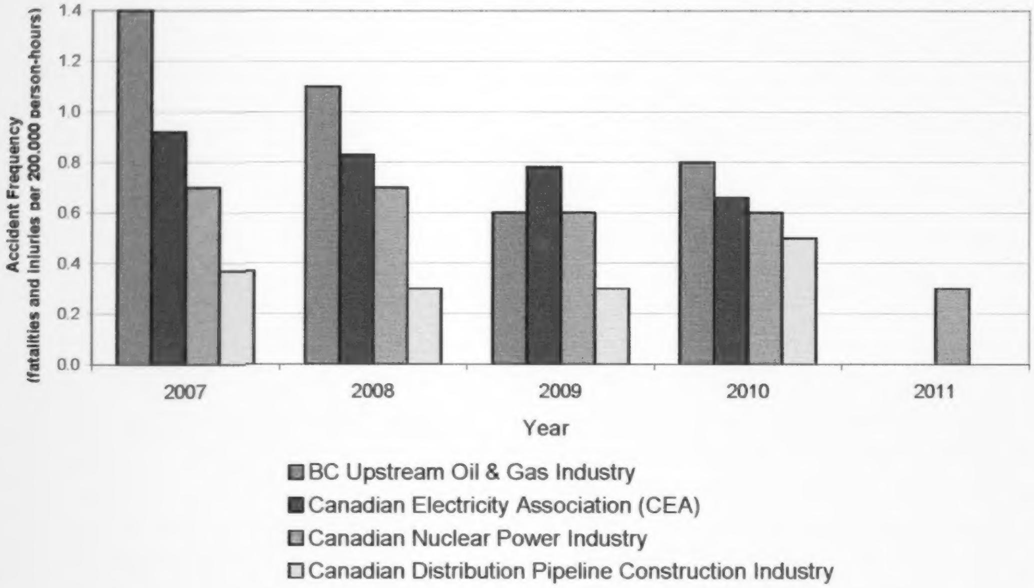
Figure 11: Trend details of accident severity rate for stations and industry



	Bruce A & B	Darlington	Pickering A & B	Gentilly-2	Point Lepreau	Industry
■ 2007	0.0	0.0	0.8	18.0	0.3	1.3
□ 2008	0.0	3.4	2.2	6.0	0.0	1.7
▨ 2009	0.0	0.0	0.5	0.0	0.9	0.3
■ 2010	0.0	0.0	0.6	7.0	0.0	0.8
▒ 2011	4.6	0.0	0.2	7.0	0.0	1.9

Figure 12 shows the AF values for the Canadian nuclear power industry from 2007 to 2011 in comparison with values from selected energy-related Canadian industries. The Canadian industries shown in the figure include members of the Canadian Electricity Association (CEA), the BC upstream oil and gas industry, and the Canadian distribution pipeline construction industry. The comparison shows that the Canadian nuclear power industry has maintained its AF value relatively low in comparison to other Canadian industries. This is an indication of how effective the health and safety programs at NPPs are at reducing the number of accidents that result in injuries.

Figure 12: Trend details of accident frequency for Canadian industries



CNSC staff observed that for the nuclear power industry the AF decreased while the ASR increased. CNSC staff concluded that the conventional health and safety SCA for the industry was effective and that observed deficiencies are being addressed by licensees.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety programs at NPPs met regulatory requirements and, at Bruce A and B and Darlington, exceeded regulatory requirements.

1A.9 Environmental protection

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA

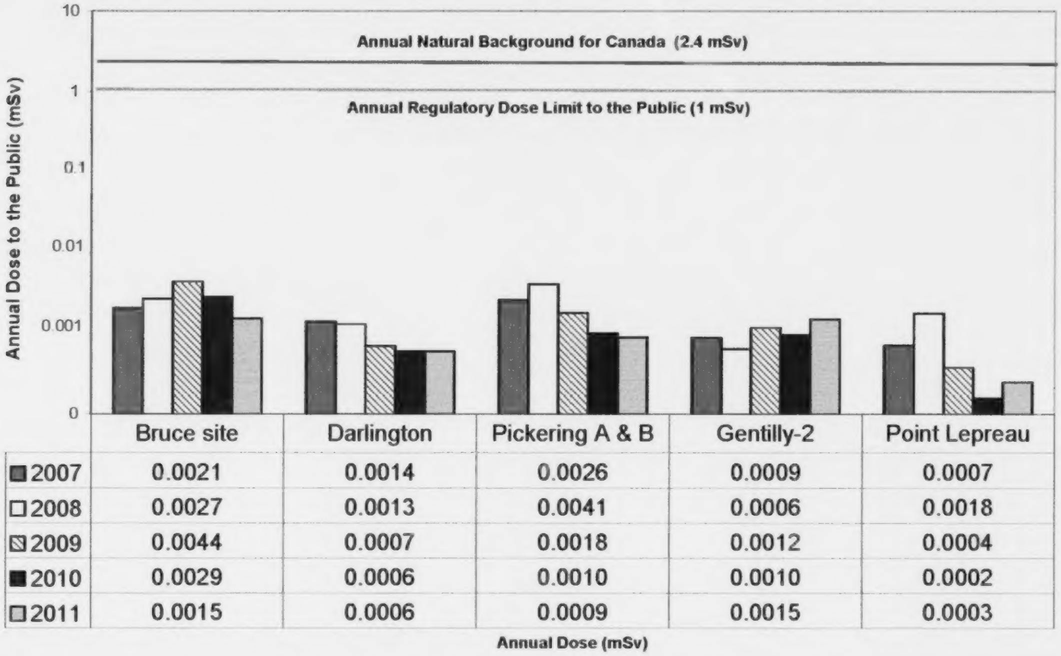
The environmental protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances and the effects on the environment from facilities or as the result of licensed activities. The industry average rating for environmental protection was "satisfactory" in 2011, unchanged from the previous year.

Environmental protection encompasses the following specific areas: environmental management system, estimated dose to the public, environmental risk assessment, effluent and emissions control (releases), and environmental monitoring.

Environmental management system
There were no significant observations from compliance verification activities to report in this specific area for 2011.

Estimated dose to the public
The dose to the public from each Canadian NPP for both airborne emissions and liquid releases from 2007 to 2011 is provided in figure 13. The figure shows that the doses to the public are well below the regulatory public annual dose limit of 1 mSv and negligible in comparison to the amount of radiation dose Canadians receive from natural background radiation sources (2.4 mSv). The comparison shows that the 2011 dose to the public values for Canadian NPPs are lower than or equal to the 2007 to 2010 values for most stations.

Figure 13: Comparison of dose to public from Canadian nuclear power plants, 2007 to 2011



	Bruce site	Darlington	Pickering A & B	Gentilly-2	Point Lepreau
■ 2007	0.0021	0.0014	0.0026	0.0009	0.0007
□ 2008	0.0027	0.0013	0.0041	0.0006	0.0018
▧ 2009	0.0044	0.0007	0.0018	0.0012	0.0004
■ 2010	0.0029	0.0006	0.0010	0.0010	0.0002
□ 2011	0.0015	0.0006	0.0009	0.0015	0.0003

Annual Dose (mSv)

Environmental risk assessment

During 2011, OPG submitted the environmental impact statement and technical support documents for the screening environmental assessment for the proposed Darlington refurbishment and continued operation project. CNSC staff are reviewing these documents.

Effluent and emissions control (releases) and environmental monitoring

Airborne emissions and liquid releases for 2011 are shown in figures 14 and 15, respectively. Note that a logarithmic scale is used for the purpose of direct comparison of the radionuclides. Licensees establish action levels that are set at 10 percent of the derived release limits (DRLs). The DRLs are stated in each operating licence and are given for the NPPs in appendix E, "Derived Release Limits (DRLs) for Canadian NPPs". These action levels, if reached, would indicate a loss of control of part of the licensee's environmental program and the need for specific actions to be taken and reported to the CNSC. However, releases exceeding the DRLs would remain well below regulatory limits. All releases in 2011were well below action levels and almost negligible in comparison with the regulatory limits.

Figure 14: Radionuclides emitted to air by Canadian nuclear power plants in 2011

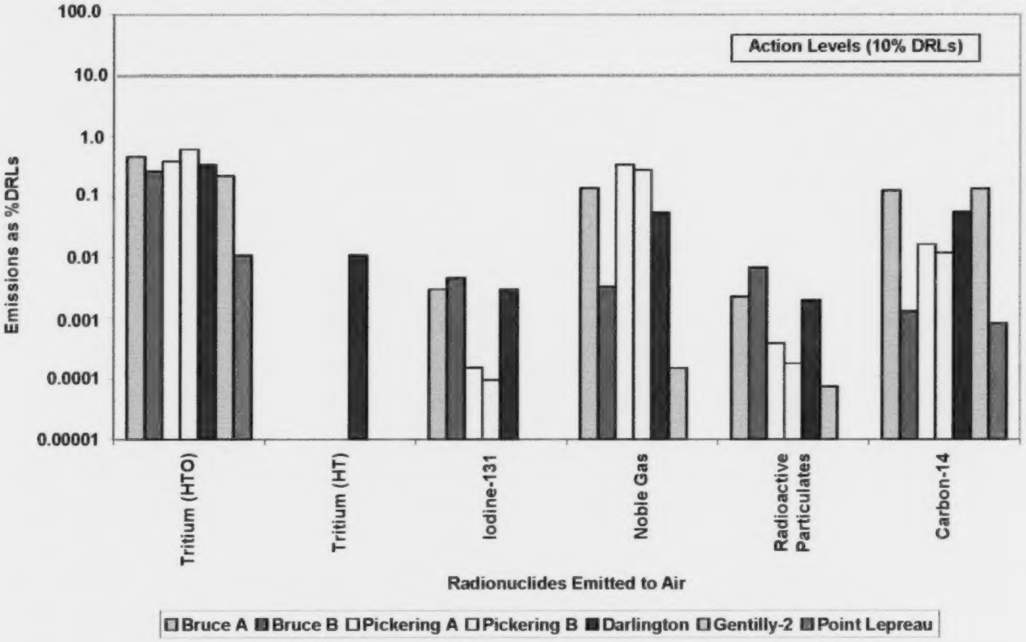
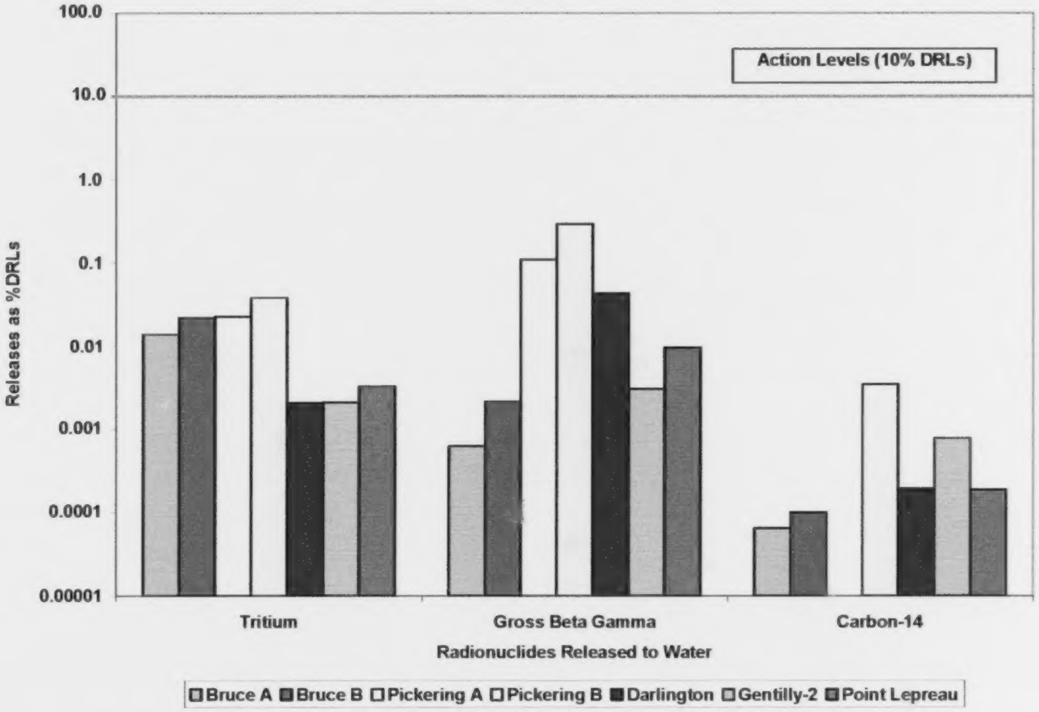


Figure 15: Radionuclides released to water by Canadian nuclear power plants in 2011



Overall, based on the information assessed, CNSC staff concluded that the implementation of the environmental protection programs at NPPs met regulatory requirements.

1A.10 Emergency management and fire protection

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA	SA

The emergency management and fire protection SCA covers emergency plans and emergency preparedness programs for dealing with radiological, nuclear and conventional emergencies, and also includes the results of exercise participation during the year. For the specific area of fire protection and response, only the performance of the fire response organization is addressed in this SCA; design issues are described under section 1A.5, Physical design. Based on the data collected, and the observations made during CNSC inspections, the industry average for emergency management and fire protection was rated as "satisfactory" for 2011, unchanged from the previous year.

Emergency management and fire protection encompasses the following specific areas: nuclear emergency management, conventional emergency response, business continuity, and fire protection and response.

Nuclear emergency management

CNSC staff concluded from the results of inspections and observations from emergency exercises conducted during the year that there were no significant observations from compliance verification activities for the industry in this area.

Conventional emergency response

There were no significant observations from compliance verification activities to report in this specific area for 2011.

Business continuity

To meet their business continuity requirements, industry licensees have created pandemic response plans. These response plans provide assurance that adequate staff and resources will be available to provide business continuity during an influenza pandemic. During 2011, one licensee's pandemic response plan was reviewed by CNSC staff and was determined to be "satisfactory" for maintaining business continuity.

Fire protection and response

During 2011, Canadian NPP licensees continued to maintain and improve their fire response capabilities at their respective facilities. This was measured against the expectations as defined in the regulatory criteria set out in operating licences and licence conditions handbooks. The fire response programs were maintained through training programs, drills and exercise programs. In particular, Point Lepreau worked throughout 2011 to improve its emergency response team capability, performance and training, which had fallen to a rating of "below expectations" in 2010. CNSC staff have closely monitored the effectiveness of the corrective actions as part of their return-to-service regulatory oversight activities. As a result of these improvements by the licensee, Point Lepreau received a "satisfactory" rating for emergency management and fire protection in 2011.

CNSC staff concluded that all operating Canadian NPPs continued to maintain mature emergency preparedness and fire protection programs that met industry standards and CNSC regulatory performance expectations in 2011.

Overall, CNSC staff concluded that NPP licensees maintain and implement comprehensive and well-documented emergency management programs at their facilities that met regulatory requirements.

1A.11 Waste management

Safety and control area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry average**
	A	**B**		**A**	**B**			
Waste management	SA	SA	SA	SA	SA	SA	SA	SA

The waste management SCA covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility. This SCA also covers any planning for eventual decommissioning of the facility. The industry average rating for the waste management SCA in 2011 was "satisfactory", unchanged from the previous year.

Waste management encompasses the following specific areas: waste minimization, segregation and characterization; waste storage and processing; and decommissioning plan.

Waste minimization, segregation and characterization

In 2011, CNSC staff inspections noted minor areas for improvement in waste minimization, segregation and characterization, but these findings did not have an effect on the overall effectiveness of the program. CNSC staff are satisfied that the industry has taken the necessary steps to ensure that its waste management programs are implemented effectively.

Waste storage and processing

During the reporting period, CNSC staff found no significant compliance issues in this area for the industry.

Decommissioning plan

Decommissioning consists of those actions taken in the interest of health, safety, security and the environment, to retire a licensed facility or site permanently from service and render it to a predetermined end-state condition.

In accordance with the *Class I Nuclear Facilities Regulations*, all power reactor licensees must maintain an acceptable decommissioning plan, which details how the nuclear facility will be decommissioned. Decommissioning plans must remain current and must be revised within a five-year review cycle, or when required by the Commission Tribunal or a person authorized by the Commission Tribunal. This is done to incorporate operational experience, technological advances, and changes in the planning assumptions.

CNSC staff observed that the decommissioning plans for all Canadian NPPs remained valid and current during 2011. In addition, all decommissioning plans were revised within the last five-year period, as required.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the waste management programs at NPPs met regulatory requirements.

1A.12 Security

Safety and control area	**Rating**								
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry average**
	A	**B**		**A**	**B**			
Security	**FS**	**FS**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**

The security SCA covers the programs that licensees are required to implement and that support the security requirements stipulated in the regulations, in their licences, in orders, or in expectations for their facility or activity. The industry average rating for security was "satisfactory" in 2011, unchanged from the previous year. Two stations, Bruce A and B, were rated "fully satisfactory", also unchanged from the previous year.

Security encompasses the following specific areas: facilities and equipment; access control; training, exercises and drills; and nuclear response force.

In 2011, security assessments for most stations were "satisfactory", with Bruce A and B each achieving a "fully satisfactory" rating, unchanged from the previous year. Overall, the security SCA has improved across the industry in 2011.

Facilities and equipment

CNSC staff concluded that the facilities and equipment area for the industry was effective in 2011.

Access control
Site access clearance programs were in accordance with regulatory requirements and expectations as verified through inspections. The industry met the requirements of the *Nuclear Security Regulations*.

Training, exercises, and drills
The CNSC continued to utilize the Canadian Adversary Testing Team (CATT) during these performance testing exercises, to play the role of a credible adversary in safe, realistic and challenging scenarios.

The program will continue to evolve to ensure that testing remains current and relevant and that all aspects of the physical protection system (detection, delay and response) are realistically tested and assessed.

Nuclear response force
During the reporting period, CNSC staff did not identify any significant observations from compliance verification activities for the industry in this area.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the security programs at NPPs met regulatory requirements and, at Bruce A and B, exceeded regulatory requirements.

1A.13 Safeguards

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Safeguards	SA	SA	SA	SA	SA	SA	SA	SA

The safeguards SCA covers the programs required for the successful implementation of the obligations arising from the Canada/IAEA safeguards agreements. The industry average rating for safeguards was "satisfactory" in 2011, unchanged from the previous year.

The safeguards SCA consists of a system of inspection and other verification activities undertaken by the International Atomic Energy Agency (IAEA) to evaluate a state's compliance with its obligations in accordance with its safeguards agreement with the IAEA. Canada has entered into safeguards agreements with the IAEA in accordance with its obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* [15]. The objective of the Canada/IAEA safeguards agreements is for the IAEA to provide annual assurance to Canada and to the international community that all declared nuclear material is in peaceful, non-explosive uses and that there is no indication of undeclared nuclear material or activities. The CNSC is the governmental authority responsible for implementing the Canada/IAEA safeguards agreements.

The IAEA's findings and conclusions for Canada as a whole are presented to the IAEA Board of Governors each June in the *Safeguards Implementation Report*. The IAEA completed its 2011 assessment of NPPs in Canada, and all stations received a positive overall result.

To implement safeguards requirements at the facility level, the CNSC requires that licensees put a program and appropriate procedures in place to ensure that safeguards can be implemented effectively and in a manner consistent with Canada's obligations. These requirements are described in the *Nuclear Safety and Control Act*, regulations, the facility's licence (and licence conditions handbook, where appropriate), and CNSC regulatory documents. For the safeguards SCA, CNSC staff evaluate the licensee's program and procedures and their implementation in order to assess compliance with the regulations and licence conditions.

In 2010, the CNSC introduced regulatory document RD-336, *Accounting and Reporting of Nuclear Material* [16], and an associated guidance document. The regulatory document ensures consistency in record-keeping and reporting of nuclear material, in accordance with Canada's international obligations, and sets out the requirements for accurate and standardized accountancy of nuclear material inventories and flows. Outreach meetings were held with licensees in August and December 2011 to assist licensees with progress towards full compliance by July 1, 2012, the implementation deadline for all NPPs.

CNSC staff noted the strong performance of all NPPs in the timely submission of their nuclear material accountancy reports and further noted the substantial effort and progress made in working towards full RD-336 [16] compliance.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the safeguards programs at NPPs met regulatory requirements.

1A.14 Packaging and transport

Safety and control area	**Rating**							
	Bruce		**Darlington**	**Pickering**		**Gentilly-2**	**Point Lepreau**	**Industry average**
	A	**B**		**A**	**B**			
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA

The packaging and transport SCA pertains to programs that cover the safe packaging and transport of nuclear substances and radiation devices to and from the licensed facility. The industry average rating for this SCA was determined to be "satisfactory" in 2011, unchanged from the previous year.

Nuclear substances originating from NPPs are transported using packages that meet CNSC regulatory requirements and, in some cases, the package designs have been certified by the CNSC. Common shipments include transport of substances contaminated with radioactive materials in liquid and solid form, samples containing nuclear substances and tritiated heavy water.

NPP licensees are required to have appropriate training for personnel involved in the handling and transport of dangerous goods and are required to issue a training certificate to those workers in accordance with the *Transportation of Dangerous Goods Regulations* [17] (TDGR).

NPP licensees are also required to comply with both the *Packaging and Transport of Nuclear Substances Regulations* (PTNSR) and the TDGR [17] requirements for all shipments of nuclear substances leaving their site. The PTNSR apply to the packaging and transport of nuclear substances, including the design, production, use, inspection, maintenance and repair of packages, and the preparation, consigning, handling, loading, carriage and unloading of packages.

In 2011, all NPP licensees prepared and maintained documentation demonstrating that the packages used to transport nuclear substances met the requirements specified in the PTNSR and TDGR. CNSC staff did not identify any deficiencies in this area.

Overall, based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport programs at NPPs met regulatory requirements.

1B – Station performance

This section is organized by station, with performance ratings provided for each SCA. The ratings reflect CNSC staff's evaluation of how well licensees' programs met regulatory requirements and expectations to protect the overall health, safety and security of Canadians and the environment, in addition to meeting Canada's international commitments on the peaceful use of nuclear energy.

The safety performance ratings were determined by using a risk-informed approach of integrating findings from Type I and Type II inspections, reportable events, and desktop reviews of events as well as progress on enforcement actions by CNSC staff.

For specific areas within the SCAs where there were no significant observations from compliance verification activities, no information is given in this part of the report.

1B.1 Bruce A and Bruce B

The Bruce A and B sites are grouped together for this report because the same operator, Bruce Power, is licensed to operate and use common programs at both stations. However, because the implementation of some programs may be different for Bruce A and Bruce B, performance of each station is assessed separately.

At Bruce A, only Units 3 and 4 were operational in 2011. The refurbishment of Units 1 and 2 was near completion and restart of both units is scheduled for mid-2012. At Bruce B, all four units were operational.

The 2011 safety performance ratings for Bruce A and B are shown in table 5. All SCAs received "satisfactory" or "fully satisfactory" performance ratings. "Fully satisfactory" ratings were achieved in two SCAs, (i) conventional health and safety, and (ii) security. The calculation of the ratings was performed using the individual ratings for each finding in a SCA. The integrated plant ratings for both Bruce A and B were "satisfactory" for 2011, unchanged from the previous year.

No serious process failures occurred at Bruce A and B during 2011. No worker or member of the public received a dose in excess of the regulatory dose limits, and all radiological releases were well below regulatory limits and station action levels.

Bruce Power reported events as per requirements of S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and conducted appropriate follow-up, including root-cause analyses and, as needed, implemented corrective actions. Bruce Power also complied with licence conditions in accordance with Canada's international safeguards obligations during the year.

Based on these observations and assessments of the SCAs, CNSC staff concluded that Bruce A and B operated safely in 2011.

Table 5: Performance ratings for Bruce A and B for 2011

Safety and control area	**Rating**		**Industry average**
	Bruce A	**Bruce B**	
Management system	SA	SA	SA
Human performance management	SA	SA	SA
Operating performance	SA	SA	SA
Safety analysis	SA	SA	SA
Physical design	SA	SA	SA
Fitness for service	SA	SA	SA
Radiation protection	SA	SA	SA
Conventional health and safety	FS	FS	SA
Environmental protection	SA	SA	SA
Emergency management and fire protection	SA	SA	SA
Waste management	SA	SA	SA
Security	FS	FS	SA
Safeguards	SA	SA	SA
Packaging and transport	SA	SA	SA
Integrated plant rating	SA	SA	SA

1B.1.1 Management system

The management system SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Management system

The Bruce A and B operating licences require compliance with the CSA management system requirement standard N286-05 [2]. CNSC staff verified Bruce Power's compliance with this standard, focusing on the implementation of an adequate quality assurance program.

As per the requirements of CSA N286-05 [2], vendors used for the procurement of items and services must implement an adequate quality assurance program. Bruce Power uses the services of the CANDU Procurement Audit Committee (CANPAC) and the Nuclear Procurement Issues Committee (NUPIC) to audit suppliers and service providers and to assess their implemented quality assurance programs or management systems. The CNSC reviewed Bruce Power's documentation regarding the oversight being applied to CANPAC and NUPIC and did not identify any deficiencies in this area.

Organization and change management
Bruce Power continues to make improvements to the implementation of its Corporate Functional Area Manager (CFAM) organization structure. CNSC staff performed a Type II inspection to assess the implementation and concluded that the CFAM roles and responsibilities are meeting the requirements and the process itself is working effectively. Issues identified regarding requirements related to management system were properly addressed by Bruce Power's staff during the year.

Based on the information assessed, CNSC staff concluded that the implementation of the management system at Bruce A and B met regulatory requirements.

1B.1.2 Human performance management

The human performance management SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Personnel training
Bruce A and B had sufficient numbers of personnel for all required job areas. Personnel were properly trained and had the necessary knowledge and skills to carry out duties safely and adequately.

Personnel certification and certification examination and requalification testing
The personnel certification examination and requalification testing programs met the requirements for the purpose of initial certification of workers and the renewal of certifications. No significant safety issues with respect to this SCA were identified at either station. The personnel certification processes and procedures were found to be adequate overall despite identified issues related to on-the-job training. Bruce Power's overall pass rate was 96 percent for requalification tests and 97 percent for initial examination.

Human performance programs
CNSC staff reviewed Bruce Power's validation report of its abnormal incident manual and identified some issues with the systematic analysis of the most resource-intensive events. Bruce Power will continue to address the gaps identified in order to ensure an adequate minimum shift complement is available at all times to respond to all credible events.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance program at Bruce A and B met regulatory requirements.

1B.1.3 Operating performance

The operating performance SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Conduct of licensed activities
Bruce Power's operational activities are governed by their *Operating Policies and Principles* (OP&Ps) document, as referenced in the operating licences of Bruce A and B. These documents govern how the stations will operate, maintain and modify station systems to maximize nuclear safety and to keep the risk to the public acceptably low. In 2011, both the Bruce A and B stations continued to operate safely. The stations operated within their OP&Ps and within the reactor power limits prescribed by their operating licences.

Bruce A experienced three unplanned reactor trips, no stepbacks and six setbacks, while Bruce B experienced no unplanned reactor trips, one stepback and two setbacks. CNSC staff verified that, for all these events, Bruce Power staff followed approved procedures, investigated or evaluated the reason for the plant transient and took appropriate corrective actions. Stepbacks and setbacks were controlled properly and power reduction was automatically initiated by the reactor control systems.

Outage management performance
Bruce A experienced five forced outages, and Bruce B experienced two forced outages. There were no serious process failures at either station. Overall, outage implementation, safety and work management met requirements. There was one planned outage at Bruce A for Unit 3, and four planned outages at Bruce B for Units 5 to 8.

Bruce Power completed all outages successfully and met the requirements for verification of guaranteed shutdown state (GSS). CNSC staff verified and confirmed that the reactor GSS conditions were applied correctly and the application met the requirements of procedures for reactor safety. Overall, outage doses were below the ALARA targets.

Operating experience
Bruce Power's operating experience (OPEX) program met regulatory requirements. However, during inspections, CNSC staff noted that sharing of information between both stations requires improvement and recommended that Bruce Power review its internal OPEX procedures to ensure that information about events is shared between Bruce A and Bruce B stations.

CNSC staff concluded that Bruce Power operated Bruce A and B safely and in compliance with the NSCA, regulations, and conditions of the licences and the licence conditions handbooks (LCHs).

1B.1.4 Safety analysis

The safety analysis SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Deterministic safety analysis

CNSC regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], requires an update of the Safety Report within three years of the last submission. The Bruce A Safety Report was updated in 2012 and the Bruce B Safety Report was updated in 2011. NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit to the CNSC, for review, descriptions of the structures, systems and equipment at their facility in parts 1 and 2 of the Safety Report. Parts 1 and 2 of the Safety Report were submitted to the CNSC by Bruce A and B in 2009. The next update of parts 1 and 2 is expected in 2012.

Probabilistic safety assessment

Bruce Power made progress with respect to compliance with the requirements of CNSC regulatory document S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [7]. Bruce Power's submissions on probabilistic safety analysis (PSA) methodology were reviewed and accepted by CNSC staff. The PSA reports submitted by Bruce Power in December 2011 are being reviewed by CNSC staff.

In addition to the above, Bruce Power will be re-examining its safety case as a result of the Fukushima Daiichi nuclear accident; this re-examination will include a review of the range of conditions and applications of the PSA for the assessment of external events.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis program at Bruce A and B met regulatory requirements.

1B.1.5 Physical design

The physical design SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Component design

Bruce A and B confirmed that SSCs important to nuclear safety and security continued to meet their design basis in all operational states.

Equipment qualification

CNSC staff conducted a number of Type II inspections in the physical design area, including inspections focused on the implementation and sustainability of the environmental qualification (EQ) program, engineering change control and the electrical distribution system. No significant safety issues were discovered through these inspections.

The EQ program is fully implemented at the Bruce A operating units (Units 3 and 4) and at Bruce B (Units 5 to 8). EQ program implementation at Bruce A Units 1 and 2 is in progress and will be completed prior to restart of both units.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design program at Bruce A and B met regulatory requirements.

1B.1.6 Fitness for service

The fitness for service SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Maintenance

Maintenance program performance at both Bruce stations remained "satisfactory". The most challenging area with respect to system health and plant condition is maintenance backlog and aging of components. Maintenance inspections did not identify any major issues. However, CNSC staff did not see a significant decrease in the number of elective maintenance work orders and concluded that the maintenance backlogs could be improved. The preventive maintenance completion ratio for Bruce A was 87 percent, greater than the industry average value of 85 percent while for Bruce B it was 74 percent, below the industry average. Areas for improvement include work completion in preventive maintenance activities. CNSC staff will continue to focus on this area and to monitor the corrective actions that have been implemented by Bruce Power, in order to verify whether the corrective actions are decreasing the backlogs as intended.

Reliability

The reliability program implemented at Bruce Power continued to meet regulatory requirements as given in CNSC regulatory document S-98, *Reliability Programs for Nuclear Power Plants* [11].

Periodic inspections

Bruce A and B have fitness for service programs in place to ensure the integrity of pressure tubes, feeders and steam generators is maintained. Bruce Power inspects and tests pressure retaining and containment SSCs, in accordance with the station's periodic inspection program (PIP) and applicable CSA standards. CNSC staff assessed the PIP's compliance with these standards for the "return to service" project at Bruce A Units 1 and 2 and concluded that the activities proposed by Bruce Power to address issues raised by CNSC staff are "satisfactory". The remaining PIP compliance assessments addressing the submission of inspection results are being reviewed by the CNSC. However, no significant pressure boundary degradation findings were identified during the 2011 inspection campaign.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service program at Bruce A and B met regulatory requirements.

1B.1.7 Radiation protection

The radiation protection SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, an improvement for Bruce A and unchanged for Bruce B from the previous year.

Based on the assessment of findings in this SCA, CNSC staff are satisfied that Bruce Power has provided adequate protection of the health and safety of persons at Bruce A and B with respect to ionizing radiation.

Contamination control and worker dose control

No regulatory limits, action levels or administrative dose limits were exceeded during 2011. To address the tritium release event of 2010, Bruce Power purchased and installed 20 tritium-in-air alarming monitors at Bruce A and B to enhance tritium release monitoring. Response procedures were also improved.

In 2011, CNSC staff inspected the radiation protection program enhancements and the inspection team did not identify any safety significant findings or regulatory non-compliances. The inspection team did identify some opportunities for improvement to clarify program requirements in the area of personnel screening. Bruce Power has committed to implementing additional improvements in this area based on relevant operating experience (OPEX) and benchmarking best practices in nuclear facilities with mature alpha monitoring programs.

CNSC staff continued to monitor Bruce Power's long-term radiation protection program enhancements related to alpha monitoring and control. Full implementation of these enhancements is scheduled to be completed at Bruce Power by the end of 2012. The dose information for Bruce A and B is provided in section 1A.7 and appendix D.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection program at Bruce A and B met regulatory requirements.

1B.1.8 Conventional health and safety

The conventional health and safety SCA at Bruce A and Bruce B exceeded applicable CNSC requirements and performance objectives, and each station received a "fully satisfactory" rating in 2011, unchanged from the previous year.

Compliance with applicable labour codes

Bruce A and B were compliant with the applicable labour codes.

Housekeeping/management of hazards
The housekeeping/management of hazards area generally met CNSC requirements at Bruce A and B, but housekeeping has some opportunities for improvement.

Accident severity/accident frequency
Bruce A and B had an accident frequency (AF) of 0.1 in 2011, higher than the value of 0 for 2010. Moreover, the accident severity rate for Bruce A and B for this year increased to 4.6 from 0 in 2010 due to two lost-time injuries. Bruce A and B achieved the lowest AF value in the industry, a value of 0.1, which was 67 percent below the industry average. This low AF value was a result of a highly effective conventional health and safety program at Bruce A and B. The definitions for accident frequency and accident severity rate can be found in section 1A.8.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety program at Bruce A and B exceeded regulatory requirements.

1B.1.9 Environmental protection

The environmental protection SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Estimated dose to the public
In 2011, the reported dose to the public from the Bruce site (which includes Bruce A, Bruce B, Central Maintenance and Laundry Facility, Western Waste Management Facility, and the decommissioned Douglas Point reactor) was 0.0015 mSv, which is well below the public dose regulatory limit.

Effluent and emissions control (releases)
Bruce Power's revised derived release limits (DRLs) are based on the CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [18] methodology that includes dose calculations, relevant parameters, and an updated model. The DRLs are the releases to the environment that will not result in the public annual dose limit exceeding the regulatory limit of 1 mSv. Gaseous and aqueous releases of nuclear substances remained below the DRLs and monthly action levels.

Issues related to hydrazine spills occurred in this SCA. CNSC staff determined that Bruce Power took appropriate measures to address them. CNSC staff will be focusing on Bruce Power's mitigating measures and activities in this area to monitor, address and prevent future deficiencies. Legal action taken by Environment Canada for events from past years related to hydrazine spills at Bruce A and B is still before the courts.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection program at Bruce A and B met regulatory requirements.

1B.1.10 Emergency management and fire protection

The emergency management and fire protection SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Nuclear emergency management and conventional emergency response

CNSC staff performed a corporate emergency exercise inspection at Bruce Power to verify compliance with CNSC regulatory expectations in the emergency management and fire protection SCA and CNSC regulatory document RD-353, *Testing and Implementation of Emergency Measures* [19]. No action notices were issued as a result of this inspection. CNSC staff issued recommendations for correcting minor deficiencies regarding Bruce Power's emergency exercise preparation. It has been verified that the minimum shift complement was adequate for full implementation of the emergency response organization tasks and proper emergency response.

Fire protection and response

Bruce Power continued its activities to improve on fire protection issues in the inspected areas of the stations. There were no significant reportable fire events at Bruce Power.

CNSC staff concluded that Bruce Power maintains and implements a comprehensive and well-documented emergency management program at Bruce A and B that met regulatory requirements.

1B.1.11 Waste management

The waste management SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Waste minimization, segregation and characterization

Bruce Power's nuclear waste management program documents requirements for the minimization, segregation and handling, monitoring and processing of nuclear waste. The program requires the assessment of the hazard levels for all nuclear waste. Based on this assessment, all nuclear waste is disposed properly in accordance with regulations and Bruce Power's internal procedures.

Waste storage and processing

Bruce Power was in compliance with the requirements for controlling nuclear waste. CNSC staff inspections found no significant compliance issues in the waste management program. Bruce Power staff adequately responded to minor issues concerning nuclear waste bin overfilling.

Decommissioning plan

Licensees are required to maintain an acceptable decommissioning plan that sets out how a nuclear facility will be decommissioned. OPG owns the Bruce A and B sites and is therefore responsible for maintaining the decommissioning plan and the associated cost estimate that form the basis of the financial guarantee for the facilities.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management program at Bruce A and B met regulatory requirements.

1B.1.12 Security

The security SCA at Bruce A and Bruce B exceeded applicable CNSC requirements and performance objectives, and each station received a "fully satisfactory" rating in 2011, unchanged from the previous year.

Training, exercises and drills

Bruce Power has been very supportive of the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program. Bruce Power continues to have a robust nuclear response force program, and its competition team again had excellent results nationally and internationally for the year 2011. Bruce Power continues to seek methods to strengthen its overall security program and to maintain an open communication with CNSC staff, providing for timely and constructive dialogue related to ongoing and emerging issues.

Based on the information assessed, CNSC staff concluded that the implementation of the security program at Bruce A and B exceeded regulatory requirements.

1B.1.13 Safeguards

The safeguards SCA at Bruce A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Bruce Power has taken appropriate measures with respect to its licence conditions concerning Canada's international obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* [15].

The IAEA conducted a physical inventory verification (PIV) at Bruce A from June 15 to 17, 2011, to verify that no diversion of nuclear material had taken place, to detect any tampering with the IAEA's containment/surveillance system, and to confirm the declarations provided by the state authorities and facility operators. No significant compliance issues were identified.

The IAEA did not select Bruce B for a PIV in 2011. In its absence, the CNSC conducted a physical inventory taking evaluation, to provide assurance to the IAEA that the facility was properly prepared for a PIV, had it been selected.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards program at Bruce A and B met regulatory requirements.

1B.1.14 Packaging and transport

The packaging and transport SCA at Bruce A and Bruce B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Bruce Power is following packaging and transport requirements and met CNSC expectations in this area. CNSC staff performed an inspection of transportation of dangerous goods (Class 7) radioactive material to verify Bruce Power's compliance with regulatory requirements in the *Packaging and Transportation of Nuclear Substances Regulations* (PTNSR), the *General Nuclear Safety and Control Regulations* (GNSCR) and the *Transportation of Dangerous Goods Regulations* (TDGR). This inspection identified a minor issue with respect to Bruce Power's shipping program documentation. Bruce Power staff responded adequately.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport program at Bruce A and B met regulatory requirements.

1B.2 Darlington

The 2011 safety performance ratings for Darlington are shown in table 6. All SCAs received "satisfactory" or "fully satisfactory" performance ratings. "Fully satisfactory" ratings were achieved in four SCAs: (i) operating performance, (ii) fitness for service, (iii) radiation protection, and (iv) conventional health and safety. The 2011 integrated plant rating for Darlington was "fully satisfactory", unchanged from the previous year.

No serious process failures occurred at Darlington during 2011. No worker or member of the public received a dose in excess of the regulatory dose limits, and all radiological releases were well below regulatory limits and station action levels.

OPG reported events as per requirements of S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and conducted appropriate follow-up, including root cause analyses and, as needed, implemented corrective actions. Darlington complied with licence conditions concerning Canada's international safeguards obligations during the year.

Based on these observations and assessments of the SCAs, CNSC staff concluded that Darlington operated safely in 2011.

Table 6: Performance ratings for Darlington for 2011

Safety and control area	Rating	Industry average
Management system	SA	SA
Human performance management	SA	SA
Operating performance	FS	SA
Safety analysis	SA	SA
Physical design	SA	SA
Fitness for service	FS	SA
Radiation protection	FS	SA
Conventional health and safety	FS	SA
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	SA	SA
Security	SA	SA
Safeguards	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	FS	SA

1B.2.1 Management system

The management system SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Management system
OPG's operating licences require compliance with the CSA management system requirement standard N286-05 [2]. CNSC staff verified OPG's compliance with this standard focusing on the implementation of an adequate quality assurance program.

As per the requirements of CSA N286-05 [2], vendors used for the procurement of items and services must implement an adequate quality assurance program. OPG uses the services of the CANDU Procurement Audit Committee (CANPAC) and the Nuclear Procurement Issues Committee (NUPIC) to audit suppliers and service providers and to assess their implemented quality assurance programs or management systems. The CNSC reviewed OPG's documentation regarding the oversight being applied to CANPAC and NUPIC and did not identify any deficiencies in this area.

The operating licence for Darlington requires OPG to inform the CNSC of revisions made to specified management system documents that are common to all OPG NPPs. CNSC staff reviewed OPG revised charter document N-CHAR-AS-0002 R015, *Nuclear Management System*, and found the document in compliance with CSA N286-05 [2]. In addition to the revision made to the management system charter, CNSC staff were notified of changes made to 13 management system documents. CNSC staff reviewed and accepted the changes.

Management performance
In 2011, OPG resolved the deficiencies identified by a 2010 CNSC Type I inspection on independent self-assessments of management system effectiveness. OPG submitted a sample of an effectiveness review and independent audit reports that had been produced using its revised processes. CNSC staff reviewed the submissions and concluded that OPG is in compliance with the requirements of CSA N286-05 [2].

CNSC staff noted that, overall, OPG maintained a management system that integrated provisions to address all regulatory requirements to enable the licensee to achieve its safety objectives, while continuously monitoring its performance against those objectives and maintaining a healthy safety culture.

Based on the information assessed, CNSC staff concluded that the implementation of the management system at Darlington met regulatory requirements.

1B.2.2 Human performance management

The human performance management SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Personnel training

OPG has a well-documented and robust systematic approach to training (SAT). In 2011 a Type I inspection of the certification training program for responsible health physicists (RHPs)[2] and a Type II inspection of the authorized nuclear operator training program were conducted at OPG NPPs. These inspections confirmed that OPG's various training programs, including the Darlington training programs, are based on the processes and procedures that constitute its SAT-based training system. The corrective action plan to address discrepancies revealed during the Type I inspection of the certification training program for RHPs is being implemented.

Personnel certification and certification examination and requalification testing

The personnel certification examination and requalification testing programs met the requirements for the initial certification of workers and the renewal of certifications. No significant safety issues with respect to this SCA were identified at this station. The personnel certification processes and procedures were found to be adequate. CNSC staff reviewed requests for certification and found no deficiencies associated with the certification program. Darlington's overall success rate in both initial certification examinations and requalification tests was 100 percent. Furthermore, the findings from an inspection conducted by CNSC staff demonstrated that the requirements for the certification renewal of staff are being met.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance program at Darlington met regulatory requirements.

1B.2.3 Operating performance

The operating performance SCA at Darlington exceeded applicable CNSC requirements and performance objectives, and received a "fully satisfactory" rating in 2011, unchanged from the previous year.

Conduct of licensed activities

Darlington's operational activities are governed by the licensee's document, NK38-OPP-03600, *Operating Policies and Principles* (OP&Ps), as referenced by the operating licence. This document governs how Darlington will operate, maintain and modify station systems to maximize nuclear safety and to keep the risk to the public acceptably low. In 2011, Darlington continued to operate within the OP&Ps, and the four reactor units operated within the reactor power limits prescribed by the Darlington operating licence.

Throughout the year, CNSC staff conducted numerous inspections, including field and control room inspections. No significant operations-related issues were identified. Darlington continued to demonstrate a high degree of compliance in this area.

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[2] "responsible health physicist" (RHP) is an OPG term equivalent to "senior health physicists" (SHP) introduced in section 1A.2.

Outage management performance

One planned maintenance outage and two forced outages occurred. Darlington experienced one unplanned reactor trip, one stepback and three setbacks in 2011. Darlington's outage management conformed to the conditions prescribed by its operating licence and all outage-related undertakings were conducted safely.

Tritium removal facility (TRF)

Darlington is the only NPP in the CANDU fleet that maintains and operates a tritium removal facility (TRF). Tritium is a radioactive by-product that gradually builds up as a result of day-to-day operations of CANDU reactors. The TRF is designed to minimize the amount of tritium released into the environment, as well as reduce the potential radiation exposure of workers. The TRF extracts tritium from the heavy water used in the reactors. The extracted tritium is then safely stored in stainless steel containers within a concrete vault. The operation of the TRF did not exceed any environmental limits.

CNSC staff concluded that OPG operated Darlington safely, in compliance with the NSCA, regulations, and conditions of the licence, and exceeded regulatory requirements for this SCA.

1B.2.4 Safety analysis

The safety analysis SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Deterministic safety analysis

CNSC regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], requires an update of the Safety Report within three years of the last submission. The Safety Report for Darlington was updated in 2009. NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit to the CNSC, for review, descriptions of the structures, systems and equipment at their facility in parts 1 and 2 of the Safety Report. Darlington submitted these descriptions in 2010.

OPG continues to make satisfactory progress in resolving a number of ongoing safety analysis programs or topics, such as the safety analysis improvement (SAI) program, effects of plant aging on safety analysis and resolution of CANDU safety issues.

Probabilistic safety assessment

OPG also submitted the required methodology guides in compliance with CNSC standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [7] and these have been accepted by the CNSC. The required PSA reports were submitted prior to the December 2011 deadline and are currently being reviewed. The reviews are expected to be completed by the end of 2013.

In addition to the above, OPG will be re-examining its safety case as a result of the Fukushima Daiichi nuclear accident; this re-examination will include the review of the range of conditions and applications of the PSA for the assessment of external events.

Darlington appropriately demonstrated acceptability of the consequences and/or frequency of a wide range of internal and external events. For design-basis events and accidents, Darlington's safety analysis performance demonstrated the capability of protective systems to adequately control power, cool the fuel and contain radioactivity within the plant. Darlington's probabilistic safety assessment (PSA) that accounts for beyond-design-basis accidents demonstrated that overall plant risk is acceptably low.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis program at Darlington met regulatory requirements.

1B.2.5 Physical design

The physical design SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Component design

Darlington confirmed that SSCs important to nuclear safety and security continued to meet their design basis in all operational states.

Equipment qualification, system design and classification, and engineering change control

CNSC staff conducted a number of Type II inspections in the physical design area, including inspections focused on the implementation and sustainability of the environmental qualification (EQ) program, engineering change control and the electrical distribution system. No significant safety issues were discovered through these inspections.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design program at Darlington met regulatory requirements.

1B.2.6 Fitness for service

The fitness for service SCA at Darlington exceeded applicable CNSC requirements and performance objectives, and received a "fully satisfactory" rating in 2011, unchanged from the previous year. Darlington has fitness for service programs in place to ensure that the integrity of pressure tubes, feeders and steam generators is maintained.

Maintenance

Maintenance program performance at Darlington remained highly effective. The preventive maintenance completion ratio increased to 93 percent and is greater than the industry average value of 85 percent and the industry best practice target of 90 percent. Also, Darlington had the highest PMCR value for Canadian NPPs.

Darlington's performance in maintenance remained effective, adhering to the maintenance activities required by applicable standards referenced in the licence. CNSC staff assessments and inspections did not identify any significant maintenance-related issue.

Reliability

The reliability program implemented at Darlington continued to meet regulatory requirements as given in CNSC regulatory document S-98, *Reliability Programs for Nuclear Power Plants* [11].

Periodic inspections

OPG inspects and tests pressure retaining and containment SSCs, in accordance with the station's periodic inspection program and applicable CSA standards. No significant pressure boundary degradation findings were identified during the 2011 inspection campaign.

Lifecycle management

OPG revises the lifecycle management plans (LCMPs) annually and submits them to the CNSC for review. The LCMPs for pressure tubes, feeders, steam generators and concrete containment structure were all satisfactory at Darlington.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service program at Darlington exceeded regulatory requirements.

1B.2.7 Radiation protection

The radiation protection SCA at Darlington exceeded applicable CNSC requirements and performance objectives, and received a "fully satisfactory" rating in 2011, unchanged from the previous year.

Based on the assessment of findings in this SCA, CNSC staff are satisfied that OPG has provided adequate protection of the health and safety of persons at Darlington with respect to ionizing radiation. OPG is committed to correct signage as directed.

Contamination control

OPG developed and implemented enhancements to its radiation protection program to bring Darlington's alpha monitoring program in accordance with industry best practices. In 2011, CNSC staff inspected the radiation protection program enhancements and concluded that the program met the requirements of the *Radiation Protection Regulations* and that there were no significant deficiencies.

Worker dose control
There were no radiation exposures exceeding administrative dose limits and no incidents resulting in a reportable dose in excess of the OPG action levels. The dose information for Darlington is provided in section 1A.7 and appendix D.

CNSC staff continued to monitor Darlington's long-term radiation protection program enhancements related to alpha monitoring and control. Full implementation of these enhancements is scheduled to be completed at Darlington by the end of 2012.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection program at Darlington exceeded regulatory requirements.

1B.2.8 Conventional health and safety

The conventional health and safety SCA at Darlington exceeded applicable CNSC requirements and performance objectives, and received a "fully satisfactory" rating in 2011, unchanged from the previous year.

Compliance with labour codes
Darlington was compliant with the applicable labour codes.

Housekeeping/management of hazards
Darlington's conventional health and safety work practices and conditions achieved a high degree of personnel safety.

Darlington maintained good housekeeping and no significant safety issues were identified in this area during this reporting period.

Accident severity/accident frequency
The accident frequency decreased from 0.7 in 2010 to 0.2 in 2011. Darlington's accident severity rate remained at 0. Definitions for accident frequency and accident severity rate are found in section 1A.8.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety program at Darlington exceeded regulatory requirements.

1B.2.9 Environmental protection

The environmental protection SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Estimated dose to the public
The reported dose to the public from Darlington was 0.0006 mSv, which is well below the public dose limit of 1 mSv.

Effluent and emissions control (releases)
Gaseous and aqueous releases of nuclear substances remained below environmental action levels and derived release limits throughout the year.

Environmental monitoring
CNSC staff conducted a Type II inspection of the environmental monitoring program and concluded that Darlington met CNSC requirements.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection program at Darlington met regulatory requirements.

1B.2.10 Emergency management and fire protection

The emergency management and fire protection SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Nuclear emergency management and conventional emergency response
Darlington had sufficient provisions for emergency preparedness and response capability that would mitigate the effects of an accidental release of nuclear or hazardous substances.

Fire protection and response
Darlington implemented a comprehensive fire response capability which includes effective procedures, training and maintenance of proficiency.

CNSC review of inspection findings, surveillance monitoring and reportable events during 2011 did not identify any significant issues relating to emergency preparedness.

CNSC staff concluded that OPG maintains and implements a comprehensive and well-documented emergency management program at Darlington that met regulatory requirements.

1B.2.11 Waste management

The waste management SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Waste minimization, segregation and characterization
Darlington has a nuclear waste management program to minimize, control and properly dispose of radioactive waste. Nuclear wastes are controlled, monitored and releases are recorded.

As part of a Type II inspection, CNSC staff confirmed that the requirements relating to reduction of nuclear waste originating for alpha hazards were appropriately documented.

Waste storage and processing

Darlington has appropriately developed, implemented and audited its facility and waste stream-specific waste management program to control and minimize the volume of nuclear waste generated by the licensed activity. The licensee has also included waste management as a key component of its corporate and safety culture.

Decommissioning plan

Licensees are required to maintain an acceptable decommissioning plan that sets out how a nuclear facility will be decommissioned. OPG is responsible for maintaining the decommissioning plan and the associated cost estimate that form the basis of the financial guarantee for the facility.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management program at Darlington met regulatory requirements.

1B.2.12 Security

The security SCA at Darlington met applicable CNSC requirements and performance objectives, and received a “satisfactory” rating in 2011, unchanged from the previous year.

OPG demonstrated improvement in security for 2011 and some of the elements of their program are considered “industry leading”. It is worth noting that OPG is sharing practices with other high-security nuclear sites in the development of their security programs.

Training, exercises and drills

OPG has been notably supportive of the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

Based on the information assessed, CNSC staff concluded that the implementation of the security program at Darlington met regulatory requirements.

1B.2.13 Safeguards

The safeguards SCA at Darlington met applicable CNSC requirements and performance objectives, and received a “satisfactory” rating in 2011, unchanged from the previous year.

OPG has taken appropriate measures with respect to its licence conditions concerning Canada’s international obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* [15].

The IAEA conducted a physical inventory verification (PIV) at Darlington from November 1 to 8, 2011, to verify that no diversion of nuclear material had taken place, to detect any tampering with the IAEA's containment/surveillance system, and to confirm the declarations provided by the state authorities and facility operators. No significant compliance issues were identified.

In addition, OPG provided support for extensive IAEA equipment installations and upgrades during the year. Of particular note is the effort that went into modernizing the safeguards sealing system in the spent fuel bays of Darlington.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards program at Darlington met regulatory requirements.

1B.2.14 Packaging and transport

The packaging and transport SCA at Darlington met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

This SCA pertains to programs that cover the safe packaging and transport of nuclear substances and radiation devices to and from the licensed facility. Based on site-surveillance activities and S-99 [1] reporting, CNSC staff did not identify any issues regarding packaging and transport.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport program at Darlington met regulatory requirements.

1B.3 Pickering A and Pickering B

Pickering A and B are grouped together for this report because the operator, Ontario Power Generation (OPG), uses common programs at both stations. However, as the implementation of programs may be different for Pickering A and B, the performance of each station is assessed separately.

In 2011 at Pickering A, only Units 1 and 4 were operational. Pickering A, Units 2 and 3 are defuelled and in long-term safe storage. At Pickering B, all four units were operational.

The 2011 safety performance ratings for Pickering A and B are shown in table 7. All SCAs received "satisfactory" performance ratings. The 2011 integrated plant ratings for Pickering A and B were both "satisfactory", unchanged from the previous year.

No serious process failures occurred at Pickering during 2011. No worker or member of the public received a dose in excess of the regulatory dose limits, and all radiological releases were well below regulatory limits and station action levels.

OPG reported events as per requirements of S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and conducted appropriate follow-up, including root-cause analyses and, as needed, implemented corrective actions. OPG also complied with licence conditions in accordance with Canada's international safeguards obligations during the year.

Based on these observations and the assessments of the SCAs, CNSC staff concluded that Pickering A and B operated safely in 2011.

Table 7: Performance ratings for Pickering A and B for 2011

Safety and control area	Rating		Industry average
	Pickering A	Pickering B	
Management system	SA	SA	SA
Human performance management	SA	SA	SA
Operating performance	SA	SA	SA
Safety analysis	SA	SA	SA
Physical design	SA	SA	SA
Fitness for service	SA	SA	SA
Radiation protection	SA	SA	SA
Conventional health and safety	SA	SA	SA
Environmental protection	SA	SA	SA
Emergency management and fire protection	SA	SA	SA
Waste management	SA	SA	SA
Security	SA	SA	SA
Safeguards	SA	SA	SA
Packaging and transport	SA	SA	SA
Integrated plant rating	SA	SA	SA

1B.3.1 Management system

The management system SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Management system
OPG's operating licences require compliance with the CSA management system requirement standard N286-05 [2]. CNSC staff verified OPG's compliance with this standard, focusing on the implementation of an adequate quality assurance program.

As per the requirements of CSA N286-05 [2], vendors used for the procurement of items and services must implement an adequate quality assurance program. OPG uses the services of the CANDU Procurement Audit Committee (CANPAC) and the Nuclear Procurement Issues Committee (NUPIC) to audit suppliers and service providers and to assess their implemented quality assurance programs or management systems. The CNSC reviewed OPG's documentation regarding the oversight being applied to CANPAC and NUPIC and did not identify any deficiencies in this area.

CNSC staff reviewed OPG's revised charter document, N-CHAR-AS-0002 R015, *Nuclear Management System*, and found the document in compliance with CSA N286-05 [2]. The review identified issues requiring clarification. These issues have no influence on the safe operation of the NPP; nevertheless, CNSC staff requested that OPG improve the clarity of the document.

The operating licence for Pickering B requires OPG to inform the CNSC of revisions made to specified management system documents that are common to all OPG NPPs. In addition to the revision made to the management system charter, CNSC staff were notified of changes made to 13 management system documents. CNSC staff reviewed the changes and recommended administrative amendments to the licence, and the Commission Tribunal approved the amendments.

Organization and change management
In 2011, OPG announced that it was amalgamating Pickering A and Pickering B into a single Pickering Nuclear organization, with the objective of having one senior leadership team reporting to a single Senior Vice President. CNSC staff did not identify any management system issues stemming from these organizational changes.

Overall, OPG maintained a management system that integrated provisions to address all regulatory requirements to enable the licensee to achieve its safety objectives, while continuously monitoring its performance against those objectives, and maintaining a healthy safety culture.

Based on the information assessed, CNSC staff concluded that the implementation of the management system at Pickering A and B met regulatory requirements.

1B.3.2 Human performance management

The human performance management SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

CNSC staff are satisfied that Pickering A and B have, in all relevant job areas, sufficient personnel who possess the necessary knowledge and skills, and who have access to procedures and tools necessary to safely carry out their duties.

Personnel training
OPG has a well-documented and robust systematic approach to training (SAT). In 2011 a Type I inspection of the certification training program for responsible health physicists (RHPs)[3] and a Type II inspection of the authorized nuclear operator training program were conducted at OPG NPPs. These inspections confirmed that OPG's various training programs, including the Pickering A and B training programs, are generally being defined, designed, developed, conducted, evaluated and managed in accordance with the processes and procedures that constitute its SAT-based training system. The corrective action plan to address discrepancies revealed during the Type I inspection of the certification training program for RHPs is being implemented.

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[3] "responsible health physicist" (RHP) is an OPG term equivalent to "senior health physicists" (SHP) introduced in section 1A.2.

Personnel certification, certification examination and requalification testing

A Type II inspection of a simulator-based initial certification examination for control room shift supervisors at Pickering B was performed. This inspection revealed that the examination does not comply with all of the relevant requirements and expectations regarding the design, development, conduct and grading of certification examinations. CNSC staff requested OPG to implement a corrective action plan to address the identified deficiencies, and have planned a follow-up inspection for 2012.

The overall success rate in initial certification examinations was 78 percent and in requalification tests was 100 percent. Although some of the successful initial certification examination results were from control room shift supervisor candidates, CNSC staff are satisfied that all certified personnel are qualified. In 2010, the rate of success for the control room shift supervisor initial certification examinations at Pickering B was markedly below the historical average. CNSC staff requested that OPG conduct an investigation to determine the root cause of this observed trend. In 2011, OPG provided the results of its analysis, developed a corrective action plan, and reported on its progress in implementing this plan. By the end of the reporting period, although the majority of the pertinent corrective actions had been implemented, the rate of success has not yet returned to the historical norm. As a result, OPG made a commitment to investigate the issues further and to implement additional corrective actions in 2012.

During the review of three of the requests for initial certification submitted by Pickering B in 2011, CNSC staff identified deficiencies with the licensee's on-the-job training program for reactor operator candidates. These deficiencies are being addressed by OPG.

Work organization and job design

There were incidents where the limits to the hours of work were exceeded and occasions where the minimum shift complement (MSC) was not met during 2011. However, these incidents had no effect on plant safety. OPG has undertaken actions to provide coaching and to increase awareness to its staff on hours of work as well as MSC requirements to minimize the reoccurrence of these incidents.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance program at Pickering A and B met regulatory requirements.

1B.3.3 Operating performance

The operating performance SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Conduct of licensed activities

Pickering's operational activities are governed by the licensee's documents *Operating Policies and Principles* (OP&Ps) (NA44-OPP-03600 for Pickering A and NK30-OPP-03600 for Pickering B), as referenced by the LCH. These documents govern how the two Pickering stations will operate, maintain and modify station systems to maximize nuclear safety and to keep the risk to the public acceptably low. In 2011, Pickering continued to operate within the OP&Ps, and all the reactor units operated within the reactor power limits prescribed by the Pickering operating licences.

Throughout the year, CNSC staff conducted numerous inspections, including field and control room inspections. No significant operations-related issues were identified. Pickering A and B continued to demonstrate a high degree of compliance in this area.

CNSC staff continued to monitor issues that were discussed in previous NPP reports, including the annulus gas system leakage and the anomalous behaviour of the liquid zone control system.

Outage management performance

Pickering A experienced seven forced outages, three unplanned reactor trips, no stepbacks and six setbacks. Pickering B experienced five forced outages, three unplanned reactor trips, no stepbacks and four setbacks.

There was one planned outage at Pickering A for Unit 4 and two planned outages at Pickering B for Units 5 and 6. Pickering's outage management conformed to the conditions prescribed by its operating licence, and all outage-related undertakings were conducted safely.

During the Unit 5 planned outage and specifically during moderator refill, the concentration of gadolinium – the poison used to control reactivity – decreased unexpectedly. This decrease was due to the formation of gadolinium oxalate which was then deposited in the moderator system. The cause of the deposit was determined to be the presence of lubricating oil in the moderator system. The gadolinium deposit was partially removed by the addition of nitric acid into the moderator, using an alternative shutdown state guarantee with the shut-off rods locked in the core. This state was given a temporary approval by the Commission Tribunal. After the reactor restarted, using boron as the reactivity poison, it was held at 5 percent of full power for an extended period to burn off the remaining gadolinium.

CNSC staff concluded that OPG operated Pickering A and B safely and in compliance with the NSCA, regulations, and conditions of the licences and met regulatory requirements.

1B.3.4 Safety analysis

The safety analysis SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Deterministic safety analysis

CNSC regulatory document S-99 [1] requires an update of the Safety Report within three years of the last submission. The Pickering A Safety Report was updated in 2010 and is referenced in the Pickering A LCH. Similarly, the Pickering B Safety Report was updated in 2011 and is currently being incorporated into the new Pickering B LCH. NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit to the CNSC, for review, descriptions of the structures, systems and equipment at their facility in parts 1 and 2 of the Safety Report. Parts 1 and 2 of the Safety Report were submitted to the CNSC by Pickering A and B in 2010 and 2009, respectively.

Probabilistic safety assessment
Pickering A and B appropriately demonstrated acceptability of the consequences and/or frequency of a wide range of internal and external events. For design-basis events and accidents, Pickering A and B's safety analysis performance demonstrated the capability of protective systems to adequately control power, cool the fuel and contain radioactivity within the plant. Pickering A and B's probabilistic safety assessments (PSAs) demonstrated that overall plant risk is acceptably low.

OPG submitted the required methodology guides in compliance with CNSC standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [7], and these have been accepted by the CNSC. The required PSA reports were submitted prior to the December 2011 deadline and are currently being reviewed. The reviews are expected to be completed by the end of 2013.

OPG is required under its licence to update the Pickering A probabilistic risk assessment (PRA) to fully comply with S-294 [7] by December 31, 2013 and to update the Pickering B PRA by December 31, 2012.

In addition to the above, OPG will be re-examining its safety case as a result of the Fukushima Daiichi nuclear accident; this re-examination will include a review of the range of conditions and applications of the PSA for the assessment of external events.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis program at Pickering A and B met regulatory requirements.

1B.3.5 Physical design

The physical design SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Component design
Pickering A and B confirmed that SSCs important to nuclear safety and security continued to meet their design basis in all operational states.

Equipment qualification
CNSC staff conducted a number of Type II inspections in the physical design area, including inspections focused on the implementation and sustainability of the environmental qualification program. No significant safety issues were discovered through these inspections.

Modifications to the design or equipment for the existing nuclear facilities at Pickering A and B were made in accordance with the existing applicable codes, standards, regulations, and licence conditions.

Engineering change control

Engineering change control inspections were performed for both Pickering A and B. CNSC staff found improvements in the implementation of the related process since the last inspection, which was conducted in 2007. However, deficiencies were noted in the quality of data entry and in the adherence to procedures. In response, OPG has started an evaluation of the extent of the deficiencies and will take appropriate corrective actions.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design program at Pickering A and B met regulatory requirements.

1B.3.6 Fitness for service

The fitness for service SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Maintenance

In 2011 CNSC staff did not identify any significant maintenance-related issues. Pickering reduced the deficient maintenance backlogs and is now consistent with the industry benchmark target. CNSC staff conducted an inspection at Pickering B on maintenance planning and scheduling and concluded that, overall, Pickering B met CNSC expectations as well as the requirements of regulatory document S-210, *Maintenance Programs for Nuclear Power Plants* [10].

Pickering's performance in maintenance remained effective, adhering to the maintenance activities required by applicable standards referenced in the licence. The preventive maintenance completion ratio reached 90 percent which is the industry best practice. CNSC staff assessments and inspections did not identify any significant maintenance-related issue.

Reliability

The reliability program implemented at Pickering A and B continued to meet regulatory requirements as given in CNSC regulatory document S-98, *Reliability Programs for Nuclear Power Plants* [11]. During 2011, there were three separate problems with the Pickering A standby generators that had a significant effect on their availability. However, the performance of the Standby Class III System met the required reliability targets. OPG continues to take corrective actions to rectify the deficiencies. OPG has also shared information regarding these events with the industry, thereby contributing to operating experience and shared engineering expertise.

OPG inspected and tested pressure boundary components, containment components and concrete containment structures in accordance with the station periodic inspection program (PIP) documents and applicable CSA standards. No findings related to pressure boundary degradation at Pickering A and B were identified during the 2011 inspection campaign that posed a risk to nuclear safety. There were also no significant findings identified from CNSC staff reviews of the S-99 [1] pressure boundary reports submitted by Pickering A and B.

Periodic inspections

CNSC staff conducted an inspection on the implementation of the PIP for concrete containment structure inspections and reactor building leakage rate test (pressure test) at Pickering A and identified several areas for improvement. In general, CNSC staff concluded that the PIP for Pickering A met the requirements of CSA N287.7-96 [14].

OPG released new program documents on major components and equipment reliability, and updated their document entitled *Integrated Aging Management Program* to include these new program documents. CNSC staff reviewed and accepted the aging management plan for the concrete containment structures for Pickering A and B. CNSC staff also accepted the lifecycle and aging management strategy for fibre-reinforced plastic piping.

Lifecycle management

OPG revises the lifecycle management plans (LCMPs) annually and submits them to the CNSC for review. The LCMPs for pressure tubes, feeders, steam generators and concrete containment structure were all satisfactory at Pickering A and B.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service program at Pickering A and B met regulatory requirements.

1B.3.7 Radiation protection

The radiation protection SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Based on the assessment of findings in this SCA, CNSC staff are satisfied that OPG has provided adequate protection of the health and safety of persons at Pickering A and B with respect to ionizing radiation. OPG is committed to correct signage as directed.

Contamination control

As reported in the 2010 NPP Report, OPG developed and implemented enhancements to its radiation protection program to improve the Pickering A and B's alpha monitoring program to meet industry best practices. In 2011, CNSC staff inspected the radiation protection program enhancements and concluded that the program met the requirements of the *Radiation Protection Regulations* and that there were no significant deficiencies. Through corrective actions, OPG addressed deficiencies raised in the inspection report to the satisfaction of the CNSC staff.

Worker dose control

There were no radiation exposures exceeding administrative dose limits and no incidents resulting in a reportable dose in excess of the OPG action levels. The dose information for Pickering A and B is provided in section 1A.7 and appendix D.

CNSC staff continued to monitor Pickering A and B's long-term radiation protection program enhancements related to alpha monitoring and control. Full implementation of these enhancements is scheduled to be completed at Pickering A and B by the end of 2012.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection program at Pickering A and B met regulatory requirements.

1B.3.8 Conventional health and safety

The conventional health and safety SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Compliance with applicable labour codes

Pickering A and B were compliant with the applicable labour codes.

Housekeeping/management of hazards

Housekeeping and transient material control continued to be an issue at both Pickering A and B, as deficiencies in these areas were repeatedly observed during site staff's inspection rounds. Another concern was in the area of asbestos hazards at Pickering A. Asbestos is used in some materials and components that were installed prior to 1988. CNSC inspectors found that not all asbestos hazards were clearly identified nor were the hazards being removed in a timely manner. In response, OPG implemented an action plan to correct the deficiencies.

Accident severity/accident frequency

The accident frequency for Pickering A and B combined decreased from 0.7 in 2010 to 0.3 in 2011. Moreover, the accident severity rate decreased from 0.6 in 2010 to 0.2 in 2011. Definitions of accident frequency and accident severity rate are given in section 1A.8.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety program at Pickering A and B met regulatory requirements.

1B.3.9 Environmental protection

The environmental protection SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Estimated dose to the public
The reported dose to the public from Pickering A and B (combined) was 0.0009 mSv, which is well below the public dose limit of 1 mSv.

Effluent and emissions control (releases)
Gaseous and aqueous releases of nuclear substances remained below environmental action levels and derived release limits throughout the year.

Environmental monitoring
CNSC staff conducted a Type II inspection of the environmental effluent monitoring program and concluded that Pickering A and B met CNSC requirements.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection program at Pickering A and B met regulatory requirements.

1B.3.10 Emergency management and fire protection

The emergency management and fire protection SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Nuclear emergency management and conventional emergency response
CNSC conducted an evaluation of the site assembly, accounting, and evacuation emergency exercise held at Pickering in 2011. While some deficiencies were found, the inspection team concluded that overall, and within the scope of the exercise, OPG demonstrated its preparedness and competence to assemble, account for and evacuate station personnel.

An update on the status of the public alerting system for the Pickering A and B nuclear generating stations (NGSs) is provided in section 2.3.3.

CNSC staff concluded that OPG maintains and implements a comprehensive and well-documented emergency management program at Pickering A and B that met regulatory requirements.

1B.3.11 Waste management

The waste management SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Waste minimization, segregation and characterization, and waste storage and processing
OPG has appropriately developed, implemented and audited its facilities and waste-stream-specific waste management program to control and minimize the volume of nuclear waste generated by the licensed activity. The licensee has also included waste management as a key component of its corporate and safety culture.

In 2011, OPG took satisfactory corrective actions to resolve minor issues raised as a result of a non-nuclear hazardous waste management inspection carried out in 2010.

Decommissioning plan

Licensees are required to maintain an acceptable decommissioning plan that sets out how a nuclear facility will be decommissioned. OPG is responsible for maintaining the decommissioning plan and the associated cost estimate that form the basis of the financial guarantee for the facilities.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management program at Pickering A and B met regulatory requirements.

1B.3.12 Security

The security SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a “satisfactory” rating in 2011, unchanged from the previous year.

OPG demonstrated improvement in security for 2011 and some of the elements of their program are considered “industry leading”. It is worth noting that OPG is sharing practices with other high-security nuclear sites in the development of their security programs.

Training, exercises and drills

OPG has been notably supportive of the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

Based on the information assessed, CNSC staff concluded that the implementation of the security program at Pickering A and B met regulatory requirements.

1B.3.13 Safeguards

The safeguards SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a “satisfactory” rating in 2011, unchanged from the previous year.

OPG has taken appropriate measures with respect to its licence conditions concerning Canada’s international obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* [15].

The IAEA did not select Pickering A or B for a physical inventory verification (PIV) in 2011. In its absence, the CNSC conducted a physical inventory taking evaluation, to provide assurance to the IAEA that the facility was properly prepared for a PIV, had it been selected.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards program at Pickering A and B met regulatory requirements.

1B.3.14 Packaging and transport

The packaging and transport SCA at Pickering A and B met applicable CNSC requirements and performance objectives, and each station received a "satisfactory" rating in 2011, unchanged from the previous year.

Based on site-surveillance activities and S-99 [1] reporting, CNSC staff did not identify any issues regarding packaging and transport. Available evidence showed that OPG met CNSC requirements and expectations for its packaging and transport program at Pickering A and B.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport program at Pickering A and B met regulatory requirements.

1B.4 Gentilly-2

The 2011 performance ratings for Gentilly-2 are shown in table 8. All SCAs received a "satisfactory" performance rating. The 2011 integrated plant rating for Gentilly-2 was "satisfactory", unchanged from the previous year.

No serious process failures occurred at Gentilly-2 during 2011. No worker or member of the public received a dose in excess of the regulatory limits, and all radiological releases were well below regulatory limits.

Hydro-Québec reported events as per regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], requirements and conducted appropriate follow-up, including root cause analyses and, as needed, implemented corrective actions. Hydro-Québec also complied with licence conditions in accordance with Canada's international safeguards obligations during the year.

Based on observations and the assessments of the SCAs, CNSC staff concluded that Gentilly-2 was operated safely and in accordance with its operating licence in 2011.

Table 8: Performance ratings for Gentilly-2 for 2011

Safety and control area	Rating	Industry average
Management system	SA	SA
Human performance management	SA	SA
Operating performance	SA	SA
Safety analysis	SA	SA
Physical design	SA	SA
Fitness for service	SA	SA
Radiation protection	SA	SA
Conventional health and safety	SA	SA
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	SA	SA
Security	SA	SA
Safeguards	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	SA	SA

1B.4.1 Management system

The management system SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Management system
Hydro-Québec's operating licence requires compliance with the CSA management system requirement standard N286-05 [2]. CNSC staff verified Hydro-Québec's compliance with this standard, focusing on the implementation of an adequate quality assurance program.

As per the requirements of CSA N286-05 [2], vendors used for the procurement of items and services must implement an adequate quality assurance program. Hydro-Québec uses the services of the CANDU Procurement Audit Committee (CANPAC) and the Nuclear Procurement Issues Committee (NUPIC) to audit suppliers and service providers and to assess their implemented quality assurance programs or management systems. The CNSC reviewed Hydro-Québec's documentation regarding the oversight being applied to CANPAC and NUPIC and did not identify any deficiencies in this area.

Based on the information assessed, CNSC staff concluded that the implementation of the management system at Gentilly-2 met regulatory requirements.

1B.4.2 Human performance management

The human performance management SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Personnel training
CNSC staff monitored the progress of Gentilly-2 related to radiation protection training programs.

Personnel certification and certification examination and requalification testing
CNSC staff concluded that Gentilly-2 had sufficient personnel in all relevant job areas with the necessary knowledge and skills as well as access to procedures and tools to safely carry out their duties. No significant deficiencies were identified during inspections of the training, examination and certification programs, and these programs were found to be adequate overall. No certification examinations or requalification tests of Gentilly-2 staff were required in 2011.

Furthermore, CNSC staff carried out an evaluation of Gentilly-2 progress with respect to previous action notices related to the exam transfer for certified operators and shift supervisors. Gentilly-2 made significant progress in these areas.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance program at Gentilly-2 met regulatory requirements.

1B.4.3 Operating performance

The operating performance SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Conduct of licensed activities
Hydro-Québec's operational activities are governed by their *Operating Policies and Principles* (OP&Ps) document, as referenced in its operating licence. This document governs how the station will operate, maintain and modify station systems to maximize nuclear safety and to keep the risk to the public acceptably low.

Throughout the year, CNSC staff conducted numerous inspections, including field and control room inspections. No significant operations-related issues were identified. Gentilly-2 continued to demonstrate a high degree of compliance in this area.

Outage management performance
Gentilly-2 experienced two forced outages; however, there were no unplanned reactor trips. No stepbacks and 10 setbacks occurred at Gentilly-2 while in operation. There was one planned outage. Gentilly-2's outage management conformed to the conditions prescribed by its operating licence and all outage-related undertakings were conducted safely.

Adequacy of procedures
CNSC staff verified that, for all events, Gentilly-2 staff followed approved procedures, investigated the reasons for the plant transient and took appropriate corrective actions.

CNSC staff concluded that Hydro-Québec operated Gentilly-2 safely and in compliance with the NSCA, regulations, and conditions of the licence and the LCH.

1B.4.4 Safety analysis

The safety analysis SCA at Gentilly-2 met applicable CNSC requirements and performance objectives and received a "satisfactory" rating in 2011, unchanged from the previous year.

Deterministic safety analysis
CNSC regulatory document S-99 [1] requires an update of the Safety Report within three years of the last submission. The Safety Report for Gentilly-2 was updated in 2011. NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit to the CNSC, for review, descriptions of the structures, systems and equipment at their facility in parts 1 and 2 of the Safety Report. Gentilly-2 submitted these descriptions in 2011.

Probabilistic safety assessment

Hydro-Québec will be re-examining its safety case as a result of the Fukushima Daiichi nuclear accident; this re-examination will include a review of the range of conditions and applications of the probabilistic safety assessment of external events.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis program at Gentilly-2 met regulatory requirements.

1B.4.5 Physical design

The physical design SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Component design

Gentilly-2 confirmed that SSCs important to nuclear safety and security continued to meet their design basis in all operational states.

Equipment qualification

The Gentilly-2 environmental qualification program is currently being implemented as planned, and as required by the licence.

System design and classification

The Gentilly-2 NPP pressure boundary design program met the requirements of CSA N285.0, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants* (1995) [20], and B51, *ASME Boiler & Pressure Vessel Code, National Board of Boiler Inspectors* (2003) [21]. Commencing June 30, 2012, Hydro-Québec must comply with the requirements of the 2006 revision of N285.0 [20].

CNSC staff provided feedback to Hydro-Québec on the integrated safety review basis document.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design program at Gentilly-2 met regulatory requirements.

1B.4.6 Fitness for service

The fitness for service SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Maintenance

Maintenance program performance at Gentilly-2 continues to improve towards the target for industry best practice. The preventive maintenance completion ratio improved to 73 percent.

Reliability
The reliability program implemented at Gentilly-2 continued to meet regulatory requirements as given in CNSC regulatory document S-98, *Reliability Programs for Nuclear Power Plants* [11].

Periodic inspections
Hydro-Québec inspects and tests pressure retaining and containment SSCs, in accordance with the station's periodic inspection program (PIP) and applicable CSA standards. No significant pressure boundary degradation findings were identified during the 2011 inspection campaign.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service program at Gentilly-2 met regulatory requirements.

1B.4.7 Radiation protection

The radiation protection SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Based on the assessment of findings in this SCA, CNSC staff are satisfied that Hydro-Québec has provided adequate protection of the health and safety of persons at Gentilly-2 with respect to ionizing radiation.

Contamination control
Hydro-Québec continued to implement long-term radiation protection program enhancements to monitor and control alpha hazards. Additional information on the program enhancements is given in section 2.4.3.

Worker dose control
One exposure exceeded an action level and no exposures exceeded the administrative dose limits. However, it should be noted that these exposures were well below the regulatory limits. The dose information for Gentilly-2 is provided in section 1A.7 and appendix D.

On June 17, 2011, an incident resulted in a worker dose in excess of Gentilly-2's action level. A worker was exposed to tritium while performing leak testing on a ventilation system; "work planning" procedures had failed to identify the potential risk of internal exposures. The single exposure to tritium resulted in a dose of 2.84 mSv. As required by the *Radiation Protection Regulations*, Hydro-Québec conducted an investigation to establish what caused the action level to be exceeded; actions were identified and taken to restore the effectiveness of the radiation protection program, and CNSC staff were notified within the period specified in the licence. Based on the result of the investigation, CNSC staff determined that appropriate measures were taken by Hydro-Québec.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection program at Gentilly-2 met regulatory requirements.

1B.4.8 Conventional health and safety

The conventional health and safety SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Compliance with applicable labour codes
In 2011, Gentilly-2 complied with the relevant sections of the Quebec law, *An Act respecting occupational health and safety*, and related regulations.

Housekeeping/management of hazards
This station met CNSC expectations in housekeeping and hazard management. While conducting field inspections, CNSC staff observed minor non-compliances that, in all cases, were corrected immediately after the licensee was informed.

Accident severity/accident frequency
The accident frequency for this year remained unchanged at 1.6, and the accident severity rate was also unchanged at 7.0. The lost-time injuries occurred mostly during the outage. Definitions for accident frequency and accident severity rate are found in section 1A.8.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety program at Gentilly-2 met regulatory requirements.

1B.4.9 Environmental protection

The environmental protection SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Estimated dose to the public
The reported dose to the public from Gentilly-2 was 0.0015 mSv, which is well below the public dose limit of 1 mSv.

Effluent and emissions control (releases)
Hydro-Québec's revised derived release limits (DRLs) are based on the CSA N288.1 [18] methodology that includes dose calculations, relevant parameters, and an updated model. The DRLs are the releases to the environment that will not result in the public annual dose limit exceeding the regulatory limit of 1 mSv/yr. CNSC staff approved the new DRLs and closed the action item.

Environmental monitoring
CNSC staff continued to monitor the elements identified as needing attention through the environmental monitoring program; that is, environmental effects of the outfalls thermal plume and of fish impingement at the water intake channel of Gentilly-2.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection program at Gentilly-2 met regulatory requirements.

1B.4.10 Emergency management and fire protection

The emergency management and fire protection SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Nuclear emergency management and conventional emergency response

As a result of the annual DERAD (Défense Radiologique) emergency management exercise conducted in November 2010, the CNSC issued a directive to Hydro-Québec to correct the notification and activation processes in order to ensure that they are implemented effectively and rapidly, especially for certain groups within the emergency response team organization. During the last exercise, conducted in November 2011, CNSC staff observed that Hydro-Québec has addressed this issue adequately.

Fire protection and response

The majority of the work required on the fire water supply piping loop around the station was completed in 2011. The underground portion of the loop, built at the time of the plant construction, was replaced.

CNSC staff concluded that Hydro-Québec maintains and implements a comprehensive and well-documented emergency management program at Gentilly-2 that met regulatory requirements.

1B.4.11 Waste management

The waste management SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Waste storage and processing

Inspections of the Gentilly-2 nuclear waste facility, comprising the Radioactive Waste Storage Area, the Solid Radioactive Waste Management Facility (Phase 1) and the Irradiated Fuel Dry Storage Area, are conducted regularly.

In 2011, CNSC staff conducted two compliance inspections of the waste facility, one in May and the other in December. Some needs for improvement to the maintenance of the facilities were identified, but they do not compromise personnel health and safety. Hydro-Québec staff at Gentilly-2 were not exposed to radiation in excess of regulatory dose limits during the activities related to this SCA.

The dose rates measured along the perimeter of the Gentilly-2 radioactive waste facility fence line were well below the prescribed exposure limit (0.0025 mSv/h). The dose rates measured in contact with the surfaces of the waste storage structures, chosen at random, were also below the prescribed operating limit (0.025 mSv/h).

Decommissioning plan

CNSC staff are satisfied with the decommissioning and financial guarantee plans prepared by Hydro-Québec.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management program at Gentilly-2 met regulatory requirements.

1B.4.12 Security

The security SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Training, exercises and drills

Hydro-Québec improved its security program during the year and continues to support the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program. Hydro-Québec strengthened the overall security program at Gentilly-2 in 2011.

Based on the information assessed, CNSC staff concluded that the implementation of the security program at Gentilly-2 met regulatory requirements.

1B.4.13 Safeguards

The safeguards SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Hydro-Québec has taken appropriate measures with respect to its licence conditions concerning Canada's international obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* [15].

The IAEA did not select Gentilly-2 for a physical inventory verification (PIV) in 2011. In its absence, the CNSC conducted a physical inventory taking evaluation, to provide assurance to the IAEA that the facility was properly prepared for a PIV, had it been selected.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards program at Gentilly-2 met regulatory requirements.

1B.4.14 Packaging and transport

The packaging and transport SCA at Gentilly-2 met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

This SCA pertains to programs that cover the safe packaging and transport of nuclear substances and radiation devices to and from the licensed facility. Based on site-surveillance activities and S-99 [1] reporting, CNSC staff did not identify any issues within this area.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport program at Gentilly-2 met regulatory requirements.

1B.5 Point Lepreau

In 2011, New Brunswick Power (NB Power) continued refurbishment activities at Point Lepreau. CNSC staff continued to review, inspect and monitor NB Power's activities related to refurbishment, besides conducting ongoing reviews of licensee safety performance with respect to licence requirements.

The 2011 safety performance ratings for Point Lepreau are shown in table 9. All SCAs received "satisfactory" performance ratings. The 2011 integrated plant rating for Point Lepreau was "satisfactory", unchanged from the previous year.

No serious process failures occurred at Point Lepreau. No worker or member of the public received a dose in excess of the regulatory dose limits, and all radiological releases were well below regulatory limits and station action levels.

NB Power reported events as per requirements of regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and conducted appropriate follow-up, including root-cause analyses and, as needed, implemented corrective actions. NB Power also complied with licence conditions pursuant to Canada's international safeguards obligations during the year.

Based on these observations and the assessments of the SCAs, CNSC staff concluded that Point Lepreau operated safely in 2011.

Table 9: Performance ratings for Point Lepreau for 2011

Safety and control area	Rating	Industry average
Management system	SA	SA
Human performance management	SA	SA
Operating performance	SA	SA
Safety analysis	SA	SA
Physical design	SA	SA
Fitness for service	SA	SA
Radiation protection	SA	SA
Conventional health and safety	SA	SA
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	SA	SA
Security	SA	SA
Safeguards	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	SA	SA

1B.5.1 Management system

The management system SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Management system

NB Power's operating licence, renewed in 2012, requires compliance with the CSA management system requirement standard N286-05 [2]. This standard specifies the requirements for a management system program (replacing the QA program defined in the CSA N286 series of documents). NB Power indicated that it will be in full compliance with N286-05 by June 30, 2012. CNSC staff confirmed that the documented management system processes used by NB Power meet CNSC staff's expectations and that their implementation at Point Lepreau meets CNSC requirements.

As per the requirements of CSA N286-05 [2], vendors used for the procurement of items and services are required to implement an adequate quality assurance program. NB Power uses the services of the CANDU Procurement Audit Committee (CANPAC) and the Nuclear Procurement Issues Committee (NUPIC) to audit suppliers and service providers and to assess their implemented quality assurance programs or management systems. The CNSC reviewed NB Power's documentation regarding the oversight being applied to CANPAC and NUPIC and did not identify any deficiencies in this area.

In late 2010, NB Power submitted revision 6 of NMM-00660, *Nuclear management manual*, to CNSC staff for review and subsequent licence amendment. This manual and its related documentation provide the description of the management system implemented at Point Lepreau. The management manual and related documentation were revised to address the requirements of CSA N286-05 [2]. CNSC staff indicated that the revised manual and documentation meet the CSA standard and the operating licence was amended to include Revision 6.

Based on the information assessed, CNSC staff concluded that the implementation of the management system at Point Lepreau met regulatory requirements.

1B.5.2 Human performance management

The human performance management SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Personnel training

The CNSC observed in past evaluations and desktop reviews that although NB Power has a systematic approach to training (SAT) and adequately implemented it for operations training, it was not implemented effectively in other areas. As a result, the personnel training specific area was assessed as "below expectations" in 2010. During 2011, NB Power made considerable progress in improving its training system as well as making good progress in updating its training programs as a result of recent engineering, design and procedural changes emerging from the recent refurbishment. Consequently, based on progress to date, NB Power has been upgraded to a "satisfactory" rating in the specific area of personnel training.

Certification examination and requalification testing

The administration of certification examinations at Point Lepreau is satisfactory. The certification examinations met the minimum requirements for the purpose of initial certification of workers. The overall pass rate was 92 percent for initial certification examinations and 100 percent for requalification tests.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance program at Point Lepreau met regulatory requirements.

1B.5.3 Operating performance

The operating performance SCA, which includes the management of outages, met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Conduct of licensed activities and outage management performance

The plant remained shut down as the refurbishment outage continued. The work performed during the year included retubing of the reactor as well as the completion of other systems upgrades.

Adequacy of procedures
In 2011, NB Power implemented a new management process for the evaluation of problem causes and corrective actions to be taken. The new processes established a series of formal periodic staff meetings. This new process has resulted in a reduction in the backlog of corrective action completions. Though good progress is being made to reduce the average life of outstanding corrective actions, the outstanding and overdue corrective actions were found to be significant enough for the action item to remain open. The status regarding this action item will be evaluated by CNSC staff prior to the restart of the station in 2012.

CNSC site staff activities during the year included surveillance and monitoring, walk-down inspections, and verification of installation and commissioning of modifications and upgrades.

CNSC staff concluded that NB Power operated Point Lepreau safely and in compliance with the NSCA, regulations, and conditions of the licence and the LCH.

1B.5.4 Safety analysis

The safety analysis SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a “satisfactory” rating in 2011, unchanged from the previous year.

Deterministic safety analysis
CNSC regulatory document S-99 [1] requires an update of the Safety Report within three years of the last submission. The Safety Report was updated by NB Power and submitted to the CNSC in 2009 and is referenced in the licence conditions handbook (LCH). NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit to the CNSC, for review, descriptions of the structures, systems and equipment at their facility in parts 1 and 2 of the Safety Report. These were submitted to the CNSC by NB Power for Point Lepreau in 2009. The next update is required by the end of 2012.

Probabilistic safety assessment
NB Power continued to make adequate progress in safety analysis related to refurbishment activities and in a number of ongoing safety analysis programs or topics, such as compliance with CNSC regulatory document S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [7], in the area of probabilistic safety assessment (PSA), safety analysis improvement (SAI) program, safe operating envelope and the effect of plant aging on safety analysis. With the renewal of the Point Lepreau licence in 2012, deterministic and probabilistic safety assessment programs, as well as safe operating envelope requirements, are included as licence conditions.

In addition to the above, NB Power will be re-examining its safety case as a result of the Fukushima Daiichi nuclear accident; this re-examination will include a review of the range of conditions and applications of the PSA for the assessment of external events.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis program at Point Lepreau met regulatory requirements.

1B.5.5 Physical design

The physical design SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

System design and classification
Many design improvements were made as part of the Point Lepreau Refurbishment (PLR) project to extend the operating life of the Point Lepreau by 25 to 30 years. The major activity planned for the outage, referred to as "retube", was completed in 2011. The PLR project also included a number of repairs, replacements, inspections and upgrades, as well as other routine operations and maintenance activities.

During 2011, NB Power completed the installation of calandria tubes, pressure tubes, and feeder pipes. The replaced components incorporate some design improvements and updated specifications intended to enhance performance (shutdown system enhancements, fuel channel components and feeder enhancements, fire detection, suppression and egress improvements, and upgrades to seismic robustness). CNSC staff reviewed and accepted the design description, design requirement and design specification documents for the retube components (fuel channels, feeders and calandria tubes).

Upgrades were made in response to beyond-design-basis accidents, such as calandria vault makeup line, emergency filtered vent system, hydrogen recombiners, main control room filtering system, and post-accident sampling and monitoring equipment.

CNSC staff conducted a Type II inspection on the electrical distribution system. The two findings related to the batteries and emergency power generators mission test are currently being addressed by NB Power.

Fire protection design
NB Power is also implementing fire design improvements in accordance with CSA N293-07 [9] and is expected to be fully compliant by the end of 2014. Compensatory measures are in place until then.

Human factors in design
NB Power has demonstrated continued improvements in human factors (HF) both in design process and process implementation. However, there are still areas for further improvement, specifically validation of HF designs and assessment of contractor HF designs. These areas will be monitored by CNSC staff.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design program at Point Lepreau met regulatory requirements.

1B.5.6 Fitness for service

The fitness for service SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Maintenance

Point Lepreau remained in a shutdown state for refurbishment in 2011. CNSC staff assessments and inspections did not identify any significant maintenance-related issue. The preventive maintenance completion ratio was satisfactory during 2011, and was 88 percent.

Reliability

The reliability program implemented at Point Lepreau continued to meet regulatory requirements as given in CNSC regulatory document S-98, *Reliability Programs for Nuclear Power Plants* [11].

Lifecycle management

The lifecycle aging management programs for pressure tubes, feeders, steam generators and concrete containment structure were all satisfactory. NB Power is currently revising the pressure tube and feeder-related aspects of its lifecycle management programs and intends to submit a new fuel channel plan for CNSC review within 90 days of the end of the refurbishment outage.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service program at Point Lepreau met regulatory requirements.

1B.5.7 Radiation protection

The radiation protection SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Based on the assessment of findings in this SCA, CNSC staff are satisfied that NB Power has provided adequate protection of the health and safety of persons at Point Lepreau with respect to ionizing radiation.

Contamination control and worker dose control

There were no radiation exposures exceeding administrative dose limits and no incidents resulting in a reportable dose in excess of NB Power's action levels. The refurbishment activities at Point Lepreau are expected to be completed within the estimated project dose of 12.7 person-sieverts.

On December 13, 2011, a small spill (4 to 6 litres) of heavy water occurred within the reactor containment building at Point Lepreau due to a configuration control error. As a result of this spill, CNSC staff conducted a focused inspection on the actions taken to protect the health and safety of persons and the environment. The CNSC determined that NB Power took all reasonable precautions to protect the environment and the health and safety of persons and to control the release of nuclear substances resulting from this spill. The highest maximum dose to a member of the cleanup crew was estimated at 0.1 mSv; that is, 0.2 percent of the annual regulatory dose limit for nuclear energy workers.

NB Power continues to implement long-term radiation protection program enhancements to monitor and control alpha hazards and to align the Point Lepreau program with industry best practices. Full implementation of the program enhancements is scheduled to be completed at Point Lepreau by the end of 2012. Protective and control measures are in place to protect workers from alpha radiation hazards. The dose information is provided in section 1A.7 and appendix D.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection program at Point Lepreau met regulatory requirements.

1B.5.8 Conventional health and safety

The conventional health and safety SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Compliance with applicable labour codes
Point Lepreau met relevant sections of New Brunswick's *Occupational Health and Safety Act*, *Workers' Compensation Act* and *Workplace Health, Safety and Compensation Commission Act*.

Housekeeping/management of hazards
Due to refurbishment activities there is more material being stored and disposed of at Point Lepreau. However, inspections found no significant safety issues with housekeeping. Workers are wearing personal protective equipment as required.

Accident severity/accident frequency
The accident frequency at Point Lepreau decreased from 0.6 in 2010 to 0.5 in 2011. The accident severity rate remained unchanged at 0. Definitions for accident frequency and accident severity rate can be found in section 1A.8.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety program at Point Lepreau met regulatory requirements.

1B.5.9 Environmental protection

The environmental protection SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Estimated dose to the public
The reported dose to the public from Point Lepreau was 0.0003 mSv, which is well below the public dose limit of 1 mSv.

Effluent and emissions control (releases)
Gaseous and aqueous releases of nuclear substances were considerably below the environmental action levels in 2011.

In November 2011, NB Power reported a release of light water containing hydrazine to the environment. NB Power took appropriate measures to stop the spill and did a full investigation, which was subsequently reviewed by CNSC staff. Based on the nature of the event and the measures taken by NB Power, CNSC staff concluded that the event did not pose a significant risk to the environment.

On December 13, 2011, a small spill (4 to 6 litres) of heavy water occurred within the reactor containment building at Point Lepreau. CNSC staff reviewed the event and determined that the leak presented a negligible risk to the environment with no worker or public health implications. CNSC staff indicated that conservative calculations showed an airborne release of tritium of less than 0.3 percent of the weekly DRL and less than 3 percent of the more conservative action level. NB Power determined the root cause of the leak and has instituted measures whereby this type of event should not reoccur.

Environmental monitoring
The results of the environmental management system were similar to those of the previous year. Environmental monitoring is continuing onsite during the refurbishment with the estimated dose to the public and control of releases kept at low levels.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection program at Point Lepreau met regulatory requirements.

1B.5.10 Emergency management and fire protection

The emergency management and fire protection SCA at Point Lepreau met applicable CNSC requirements and performance objectives and received a “satisfactory” rating in 2011, an improvement from the previous year.

Nuclear emergency management and conventional emergency response
NB Power continued to upgrade its nuclear emergency program to full, normal operating requirements. Training and tabletop drills have been conducted for implementing the new incident command system for emergency response. Due to the ongoing refurbishment activities, a planned full-scale emergency response exercise was postponed until March 2012.

Business continuity

NB Power's Point Lepreau Pandemic Response Plan was reviewed as part of the licence renewal process and was found to be satisfactory. The Pandemic Response Plan is needed to ensure that adequate staff and resources will be available to provide business continuity if a pandemic occurs.

Fire protection and response

In the previous year's report (the 2010 NPP Report), the specific area of fire protection and response was rated as "below expectations" due to the results of a Type II inspection on emergency response team (ERT) performance, and on fire protection program design deficiencies. Note that in this year's report (the 2011 NPP Report), the fire protection design section is rated under the physical design SCA.

To ensure a proper focus on the ERT performance issue, a protocol was signed in August 2011 between the CNSC and NB Power that defined the process by which a "satisfactory" rating could be achieved with respect to the ERT performance.

The effectiveness of the corrective actions was closely monitored by CNSC staff. Improvements were noted during the latter half of 2011 and NB Power reached the "satisfactory" rating near the end of 2011.

CNSC staff concluded that NB Power maintains and implements a comprehensive and well-documented emergency management program at Point Lepreau that met regulatory requirements.

1B.5.11 Waste management

The waste management SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Waste minimization, segregation and characterization

CNSC staff are satisfied that NB Power has taken the necessary steps to minimize, segregate and characterize the nuclear wastes generated as a result of operating Point Lepreau. NB Power has its operating policies and principles (OP&P) document in place which refers to and includes its nuclear waste streams within the NPP.

Waste storage and processing

The Point Lepreau operating licence includes the solid radioactive waste management facility (SRWMF). This site is not co-located with the power reactor, so waste must be transported for a short distance on a private road. Oversight for waste transfers is maintained by CNSC staff at the Point Lepreau site office and the Wastes and Decommissioning Division in Ottawa.

Waste storage includes very short-lived storage within the NPP before being transferred for long-term storage at the SRWMF. NB Power has demonstrated consistent and compliant management and control of waste storage throughout its operations.

Decommissioning plan

CNSC staff's assessment of NB Power's 2011 revised decommissioning plan concluded that the plan adequately addressed the regulatory requirements.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management program at Point Lepreau met regulatory requirements.

1B.5.12 Security

The security SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

Training, exercises and drills

NB Power improved its security program during the year, and continues to support the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support personnel for the program.

Based on the information assessed, CNSC staff concluded that the implementation of the security program at Point Lepreau met regulatory requirements.

1B.5.13 Safeguards

The safeguards SCA at Point Lepreau met applicable CNSC requirements and performance objectives and received a "satisfactory" rating in 2011, unchanged from the previous year.

NB Power has taken appropriate measures with respect to its licence conditions concerning Canada's international obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* [15].

The IAEA conducted a physical inventory verification (PIV) at Point Lepreau from September 6 to 9, 2011, to verify that no diversion of nuclear material had taken place, to detect any tampering with the IAEA's containment/surveillance system, and to confirm the declarations provided by the state authorities and facility operators. No significant compliance issues were identified.

In addition, NB Power provided support for extensive IAEA equipment installations and upgrades during the year. Of particular note is the effort that went into arranging and planning for the installation of an unattended remote monitoring system for spent fuel transfers.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards program at Point Lepreau met regulatory requirements.

1B.5.14 Packaging and transport

The packaging and transport SCA at Point Lepreau met applicable CNSC requirements and performance objectives, and received a "satisfactory" rating in 2011, unchanged from the previous year.

This SCA includes the oversight of packaging and transportation of nuclear substances. All steps in the process are covered, from the design of the package to the unloading of the packaged device at its destination.

CNSC staff assessed the licensee's performance through an inspection on dangerous goods, and by reviewing shipping procedures and quarterly reports submitted to enable verification of compliance with the *Packaging and Transport of Nuclear Substances Regulations* (PTNSR).

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport program at Point Lepreau met regulatory requirements.

Part 2 – Regulatory Developments and Issues

Part 2 of this report provides detailed information on various regulatory developments and issues, including updates on:

- licensing
  - licence amendments
  - revisions to the licence conditions handbook (LCH)
- major projects and initiatives
- significant regulatory issues
- early notification reports (ENRs)

In recognition of the complexity and ongoing nature of many regulatory issues, information in this section is kept as current as the annual NPP Report preparation deadlines allow. Accordingly, the reporting period for part 2 is January 2011 to April 2012.

On March 17, 2011, a regulatory directive was issued by the CNSC to all licensees of major nuclear facilities under subsection 12(2) of the *General Nuclear Safety and Control Regulations* (GNSCR). In response to the accident at TEPCO's Fukushima Daiichi nuclear power plant in Japan, following the earthquake and tsunami on March 11, through the directive, licensees were requested to review the initial lessons learned from the event, re-examine the safety cases and report on implementation plans to address any significant gaps. Details of responses from the CNSC and NPP licensees following the Fukushima Daiichi nuclear accident can be found in part 3 of this report.

During the reporting period, two operating licences were renewed: Gentilly-2 in 2011 and Point Lepreau in early 2012. Of the seven operating licences issued to NPP operators, five now contain a power reactor operating licence (PROL) with an accompanying licence conditions handbook. The two stations which do not yet have the new PROL, Darlington and Pickering B, will be re-licensed by June 30, 2013.

Licensees are required to notify the CNSC about significant events. The reasons for notification range from an event that is of public and media interest, to an event that poses a potential risk to the health, safety or security of Canadians. Once deemed reportable by CNSC staff, the event is presented to the Commission Tribunal through an ENR. It is important to stress that the number of ENRs in a given year is not indicative of the safety of Canada's NPPs. For example, the events reported during 2011 and early 2012 were, in general, of low or no safety significance, and were reported predominantly as a direct result of media or public interest.

Twenty ENRs were submitted for NPP stations during the period of January 2011 to April 2012. Summary details for these ENRs are provided in the part 2 narratives for each station.

2.1 Bruce A and Bruce B

2.1.1 Licensing

The Bruce A and B power reactor operating licences (PROLs) were renewed for a five-year period on October 30, 2009 (effective until October 31, 2014), under the CNSC's licence reform project.

Licence amendments

No amendments were made to the Bruce A or Bruce B PROLs during the reporting period.

Revisions to the licence conditions handbook

One revision was made to the Bruce A licence conditions handbook (LCH), and one revision to the Bruce B LCH, from January 2011 to April 2012. All changes to the LCHs were approved by the Director General, Directorate of Power Reactor Regulation. Tables 10 and 11 show the most important changes made to the LCHs for both stations, from January 2011 to April 2012. There were no revisions made that were applicable to the Bruce B LCH only.

Table 10: Changes common to licence conditions handbooks for both Bruce A and Bruce B

Section	Description of change	Revision type
1.5	Table 1 was deleted and table 2 was modified in section 1.5 based on updates to the revision numbers of specific management programs.	Administrative
1.7	The preamble and compliance verification criteria (CVC) of section 1.7 were clarified.	Technical
5.2	In the CVC of section 5.2, notification of a change to a special safety system has been added to the last paragraph for further clarification.	Administrative
6.1	In the CVC of section 6.1, the two points outlining Bruce Power's transition plan to comply with licence condition 6.1 have been completed and therefore deleted.	Administrative
6.2	In the CVC of section 6.2, Bruce Power's transition plan to comply with licence condition 6.2 has been completed and therefore deleted.	Administrative
8.1	In the preamble of section 8.1, concerning environmental reports related to Bruce A and B, the text on categorization and regulatory reporting for spill events and monitoring has been updated. In the preamble of section 8.1, tables 2 and 3 regarding Summary of Routine Environmental Reporting were modified.	Administrative
11.1	In section 11.1 of the CVC, the last paragraph has been changed because of RD-336, *Accounting and Reporting of Nuclear Material*, which became effective January 1, 2011. Bruce Power has been granted an implementation period until July 1, 2012.	Technical
7.1	In the CVC of section 7.1, the CNSC regulatory guide G-217, *Licensee Public Information Programs*, has been added.	Administrative

Table 11: Changes to Bruce A licence conditions handbook

Section	Description of change	Revision type
6.1	In the CVC of section 6.1, clarification of the compliance of quality assurance programs has been added, as determined by system acceptance through the available-for-restart process.	Administrative

A number of editorial changes (e.g., updates to references, terms and definitions) were made to the LCHs for both stations. Changes made to the LCHs continue to remain within the licensing envelope.

2.1.2 Updates on major projects and initiatives

Bruce A environmental assessment follow-up program

Bruce Power continued to implement activities concerning the *Canadian Environmental Assessment Act* (CEAA) follow-up program. A long-term whitefish monitoring program was carried out as a part of this program in collaboration with stakeholders. The annual whitefish investigations 2010 summary was reported in November 2011.

Implementation of the Bruce A environmental assessment (EA) follow-up monitoring program continued according to plans previously approved by CNSC staff. The fourth-year report (2010) was submitted to the CNSC in September 2011. "Draft Operations Phase Monitoring Plans" were submitted for impingement and entrainment in July 2011 and "Thermal Monitoring Plan" in December 2011. Operations phase monitoring will begin on a schedule consistent with the start-up of Bruce A Units 1 and 2. A stakeholder workshop was held in August 2011 on the impingement and entrainment plan. This workshop included licensee representatives, government agency representatives, university researchers, fishery users and managers, and Aboriginal representatives. A bass spawning survey was conducted in 2011. Also, a third-year survey of bass fishing anglers was conducted in 2011 based on the results of analysis provided by the Ontario Ministry of Natural Resources.

Aboriginal consultation

CNSC staff continued to cooperate with the First Nations and Métis peoples in the Bruce region, with respect to nuclear projects, and to work together with the various Aboriginal groups to ensure personnel safety and environmental protection. With respect to the Bruce A environmental assessment program (EAP), Bruce Power and the Saugeen Ojibway Nations (SON) continued their cooperation in the development of a university research program to address the SON's concerns related to the whitefish studies. In April 2011, CNSC staff met the university research team to provide technical background and perspective to its members.

Bruce A Units 1 and 2 life extension

Bruce Power has been refurbishing Bruce A Units 1 and 2 since 2006. All major construction activities were completed in 2011 and the return to service of the units is in progress. Some of the major construction activities in each unit included:

- replacement of all 480 fuel channels, including pressure tubes, calandria tubes and end fittings
- replacement of 960 lower feeder segments for the heat transport system
- replacement of all eight steam generators
- enhancement of the neutron overpower detection capability
- installation of passive autocatalytic recombiners to mitigate hydrogen buildup during severe accidents
- replacement of obsolete components and equipment
- implementation of environmental qualification upgrades
- installation of a secondary control area
- installation of fire protection upgrades
- installation of seismic modifications

Both units are being returned to service through a systematic process that includes regulatory hold points. Regulatory hold points were established by the CNSC during licence renewal in 2009. CNSC staff consented to releasing the fuel load hold point for Unit 2 in June 2011; release of the fuel load hold point for Unit 1 followed in November. After the fuel load, Bruce Power continued with the commissioning program, which included vault pressure testing as well as filling, flushing and pressure testing the heat transport system. The hold point for release of the guaranteed shutdown state in Unit 2 was removed in March 2012.

The remaining hold points for the refurbishment project are:

- release of the guaranteed shutdown state in Unit 1
- increase of reactor power above 50 percent in both Units 1 and 2

These hold points are expected to be released in 2012, provided Bruce Power meets all necessary prerequisites. Subsequently, the units will fall under the CNSC's normal regulatory oversight processes along with the other units at Bruce A.

Bruce A Units 3 and 4 and Bruce B life extension

Bruce Power is currently in discussions with the Ontario Government to ensure that all refurbishments are coordinated in a manner to ensure the safe and successful execution of the projects. Bruce Power expects that by the end of the first quarter of 2012, more information will be available regarding the timing of future refurbishment projects.

In the meantime, CNSC staff continued to review Bruce Power's proposal for replacing the calandria and shield tank assembly. This project would mark the first time in the industry that the entire vessel, rather than individual components, would be replaced.

Bruce Power will be requested to submit a continued operation plan for Units 3 and 4 in support of re-licensing in 2014.

West-shift-plus project

The objective of implementing the west-shift-plus (WSP) project is to allow Bruce A Unit 3 fuel channels to operate safely at 92.5 percent full power beyond 174,500 effective full power hours (EFPH). The design activities undertaken for the project accounted for operation to at least 235,000 EFPH.

The WSP project will modify the west end bearing support configuration of the fuel channel and reposition the majority of the fuel channels of the original west end fittings. This will eliminate the channel elongation end-of-life issue and extend the life of the unit by several years. To accommodate shifting of the fuel channels westward, design changes to the fuel channels, feeders and feeder supports are necessary and are being implemented as part of the WSP project.

Based on the extensive range of technical and safety assessments performed as part of Bruce Power's engineering change control process, the planned design changes to the fuel channels, feeders and feeder supports are demonstrated to be acceptable. The implementation of the WSP project will have no adverse effect on the conclusions of the Bruce A Safety Report. Safety margins are not materially affected and defence in depth is maintained.

Modified 37-element fuel bundle

The modified 37-element (37M) fuel bundle concept consists of a fuel bundle where the central element (pin) diameter is reduced while other aspects of the fuel bundle design remain unchanged. The purpose of this modification is to improve thermalhydraulic performance in order to offset the effects of heat transport system aging and restore system design safety margins by improving the fuel dry-out power of the current design.

Bruce Power intends to use this fuel in the Bruce A and B reactors. Fuelling of Bruce A Units 3 and 4 and selected channels of Bruce B Units 5 to 8 is planned for January 2013, with further fuelling of Bruce A Units 1 and 2. Bruce Power is preparing to provide the supporting safety cases to CNSC staff.

Fuel channel life management project

In 2009, Bruce Power, OPG and AECL jointly initiated a comprehensive R&D project to investigate the feasibility of operating the pressure tubes beyond their current permitted life. During the reporting period, a protocol was signed which provides governing roles and responsibilities between the licensees and CNSC staff.

This project will address issues affecting life-limiting degradation mechanisms in fuel channels. Two of the highest priority areas affecting continued operation are:

- possible contact between pressure tube and calandria tube stemming from spacer integrity and/or spacer movement

- higher concentrations of deuterium in the pressure tube and their effect on material properties such as fracture toughness with increasing hours of operation

CNSC staff continued to review documentation submitted by the licensee addressing these high-priority areas in accordance with a protocol that provides governing roles and responsibilities between the licensees and CNSC staff.

2.1.3 Updates on significant regulatory issues

Alpha monitoring program

After the alpha contamination event at Bruce A in November 2009, CNSC staff concluded that Bruce Power had improved its alpha monitoring program to protect station personnel against alpha hazards and had demonstrated a commitment to implementing the enhancements to monitor and control alpha hazards. CNSC staff noted that Bruce Power's implementation of radiation protection program enhancements for alpha monitoring and control is based on current industry best practices and operating experience.

During an inspection conducted by CNSC staff, some minor deficiencies were identified with respect to reviews of personnel screening procedures, reviews of requirements for radiological event assessment, and appropriate documentation; they are now being adequately addressed. CNSC staff are continuing to monitor this program to ensure that CNSC expectations and acceptance criteria for implementation of the enhanced alpha monitoring are fully met.

Large loss of coolant accident (LLOCA) margin restoration

The nuclear power industry has proposed a path forward for the resolution of large loss of coolant accident (LLOCA) safety issues based on the composite analytical approach implementation plan, and on design and operational changes. Given the relatively long timeline associated with its completion, the CNSC has developed an interim regulatory position, in the event that research, analytical or plant operation findings with an adverse impact on LLOCA safety margins emerge during this period. The interim position will remain in effect until the recommendations of the COG LLOCA working group are accepted by the CNSC and are fully implemented by the industry.

This interim regulatory position establishes a set of action levels and acceptance criteria applicable to all nuclear stations irrespective of their existing LLOCA safety margins. The CNSC interim position on the LLOCA Safety Margins Restoration Project has been sent to Bruce Power and other licensees. Bruce Power submits annual updates for review by CNSC staff on the proposed path forward for LLOCA margin restoration.

Transport licence for decommissioned steam generators

On February 4, 2011, the Commission Tribunal issued a transport licence and certificate to Bruce Power for the shipment to Sweden, for recycling, of 16 decommissioned steam generators by ship through the Great Lakes and St. Lawrence Seaway. In making its decision, the Commission Tribunal confirmed that the risk to the health and safety of the public and the environment is negligible. The licence validity period was one year, and this transport licence has now expired.

An application was made to the Federal Court of Canada in 2011 for a judicial review of the Commission Tribunal's decision but the Federal Court has not yet made a decision. Bruce Power has currently put the steam generator shipment on hold.

Response to the Fukushima Daiichi events
In March 2011, in response to the Fukushima Daiichi events in Japan, CNSC inspectors carried out reactive, focused inspections on seismic qualification/robustness, irradiated fuel bays, fire protection, backup power and hydrogen mitigation, at Bruce A and B. Based on the inspection, CNSC staff concluded that Bruce Power is prepared to deal with potential emergencies. However, it was noted that the health of some systems needs improvement.

Thirty-six action items (AIs) applicable to NPPs were derived from recommendations 1 through 5 in the *CNSC Action Plan: Lessons Learned from the Fukushima Nuclear Accident* [22] are described in appendix F, "Status of Action Items Applicable to NPPs". Licensees aim to address and finalize these actions by December 2015.

2.1.4 Early notification reports

Four ENRs were submitted for Bruce A and B from January 2011 to April 2012. Summary details for each ENR are given in table 12. It can be seen that the ENR events were, in general, of low or no safety significance.

Table 12: Early notification reports for Bruce A and Bruce B

Subject	Brief description
Bruce A Unit 3 heavy water spill	On March 9, 2011, a Unit 3 valve packing failed, which resulted in a small heat transport system water leak and caused elevated tritium levels at the station. The leak was quickly terminated and a station alert was declared to prevent staff from entering the spill area. The spill was then cleaned up. All station personnel were required to submit bioassay samples before leaving the station, and it was concluded that no station personnel exceeded licensee action levels. This was a declaration of an alert or emergency within the NPP, where personnel or resources were mobilized by the licensee in response to an unexpected occurrence that presented a hazard to the plant's safe operation, to the environment or to the health and safety of persons.
Bruce A Unit 3 forced outage	On August 18, 2011, Unit 3 was shut down due to a Shutdown System 1 (SDS1) trip on heat transport system low flow. The event started when a feedwater flow control valve (3-43230-LCV-9) failed and closed. This reduced the flow to one of the preheaters (3-33110-HX3). Because of the reduced flow, the water temperature of the heat transport inner zone increased. The increased temperature resulted in increased boiling in some of the inner zone channels (3-33120-HD6). The increased boiling increased the back pressure of those channels, reducing the heat transport flow rate in the channels. As a result of the reduced flow, SDS1 tripped and shut down the reactor. The licensee repaired the flow control valve, and the unit was restarted and returned to service about two days later.

Subject	Brief description
Bruce A incident declared due to tritium alarm in the Auxiliary Services Building	On January 23, 2012, a heavy water operator informed the Bruce A control room that a tanker truck carrying heavy water from Bruce B, to be stored in the Bruce A Auxiliary Services Building (ASB), alarmed the detectors in the Bruce A ASB (its final destination). These tankers are never used on public roads and are dedicated exclusively to heavy water transport on the NPP site, which is considered a controlled area from a safety perspective. The origin, destination and travel path were all within the controlled Bruce site. Personnel in the Bruce A ASB were evacuated immediately upon the sounding of the tritium alarms. Surveys were performed and an exclusion boundary was established to prevent unplanned exposures.
Bruce B - Partial loss of class III and class IV power to Unit 0	On February 8, 2012, an electrical trip occurred during a scheduled test. Since the automatic backup had been isolated as part of the test, backup power was not available. This resulted in a loss of power in the common areas of Bruce A. Operators quickly took action to connect an alternate power supply. At no time did the main control room lose power or the ability to communicate outside the station. The operating units were not affected. Bruce Power determined that this was a reportable event in accordance with the Provincial Nuclear Emergency Plan and Bruce Power procedures (entry into an Abnormal Incident Manual). Notifications to the Provincial Emergency Operations Centre and the CNSC were completed as required.

2.2 Darlington

2.2.1 Licensing

The Darlington PROL was renewed in February 2008 for a five-year period (effective until February 28, 2013). Since renewal, the Darlington PROL has had 17 amendments, five of which were made during this reporting period. The Darlington PROL has not yet been issued under the new licence format with the accompanying licence conditions handbook (LCH).

Licence amendments

The Darlington operating licence was amended five times from January 2011 to April 2012. Details of the amendments are provided in table 13.

Table 13: Amendments to Darlington power reactor operating licence

Power reactor operating licence # – Effective date	Amendment requests
13.13/2013 – February 7, 2011	Replaced Revision 13 of OPG document N-CHAR-AS-0002, *Nuclear Management System* with Revision 14 in appendix B.
	Replaced Revision 8 of OPG document D-PROC-OP-0009, *Station Shift Complement* with Revision 9 in appendix B.
	Replaced Revision 4 of the *Darlington Nuclear Generating Station Security Report January 2010* with Revision 5.
13.14/2013 – March 28, 2011	Updated licence condition 3.8 to reference CSA N286-05 [2].
13.15/2013 – May 31, 2011	Replace Revision 8 of the of OPG document N-PROG-AS-0006, *Records and Document Control* with revision 9.
13.16/2013 – November 22, 2011	Replaced Revision 0 of the *Occupational Radiation Protection Action Levels for Power Reactor Operating Licence* document with Revision 1.
	Replaced Revision 14 of OPG document N-CHAR-AS-0002, *Nuclear Management System* with Revision 15 in appendix B.
	Replaced Revision 1 of Darlington NGS Safety Report: part 1 and part 2 with Revision 3 in appendix A
	Updated licence condition 5.2 (c) to reference CSA Standard N285.4-05 Update No. 1, *Periodic Inspection of CANDU Nuclear Power Plant Components.*
13.17/2013 – February 7, 2012	Replaced Revision 9 of the *Station Shift Complement* document to Revision 10.

Revisions to the licence conditions handbook

Darlington does not yet have an LCH.

2.2.2 Updates on major projects and initiatives

Modified 37-element fuel bundle

The modified 37-element (37M) fuel bundle concept consists of a fuel bundle where the central element (pin) diameter is reduced while other aspects of the fuel bundle design remain unchanged. The purpose of this modification is to improve thermalhydraulic performance in order to offset the effects of heat transport system aging and restore system design safety margins by improving the fuel dry-out power of the current design.

The demonstration irradiation was completed on March 25, 2012 when the last 37M bundles were removed from Unit 3. The final inspection report which includes the results of post-irradiation examination (PIE) remains to be submitted, but was not a prerequisite to the start of full core implementation. Subsequent to an acceptable assessment of all submitted OPG documentation, approval to start the implementation of full core load was granted by CNSC staff on May 31, 2012.

The effective safety improvement that can be credited to the modified 37-element fuel bundles is under evaluation by CNSC staff.

Refurbishment/Life extension

In 2011, a Commission Tribunal hearing was held on the environmental assessment for Darlington's proposed refurbishment and continued operation. As a result of the hearing, the Commission Tribunal, pursuant to sections 15 and 16 of the *Canadian Environmental Assessment Act*, approved the environmental assessment scoping information document. Additional information on this decision is found in CMD 2011-H-124, *Record of Proceedings – Ontario Power Generation Inc. – Environmental Assessment Scoping Information Document (Scope of Project and Assessment) for the Proposed Darlington Nuclear Generating Station Refurbishment and Continued Operation* [23].

The CNSC received OPG's environmental impact statement and technical support documents for the screening environmental assessment (EA) on December 5, 2011. They are currently being reviewed by staff from the CNSC and Department of Fisheries and Oceans, the two responsible authorities for the EA as well as other federal and provincial authorities. The CNSC *Draft Environmental Assessment Screening Report – Refurbishment and Continued Operation of the Darlington Nuclear Generating Station* was issued for public comment in early June 2012.

In October 2011, OPG submitted to the CNSC its integrated safety review (ISR) in support of plant life extension at Darlington in accordance with regulatory document RD-360, *Life Extension of Nuclear Power Plants* [24]. CNSC staff are reviewing the ISR and submitted their sufficiency review to OPG on February 6, 2012, in accordance with a protocol between OPG and the CNSC. The ISR is undergoing a staged review by CNSC staff, starting with a technical review of the code review reports submitted by OPG as part of its ISR. The next stage is a technical review of the 11 safety factor reports.

Fuel channel life management project

In 2009, Bruce Power, OPG and AECL jointly initiated a comprehensive R&D project to investigate the feasibility of operating the pressure tubes beyond their current permitted life. OPG seeks to ensure operational flexibility for its Darlington units – through compiling critical data on aging-related issues that might otherwise limit the life of their fuel channels. During the reporting period, a protocol was signed which provides governing roles and responsibilities between the licensees and CNSC staff.

This project will address issues affecting life-limiting degradation mechanisms in fuel channels. Two of the highest priority areas affecting continued operation are:

- possible contact between pressure tube and calandria tube stemming from spacer integrity and/or spacer movement
- higher concentrations of deuterium in the pressure tube and their effect on material properties such as fracture toughness with increasing hours of operation

CNSC staff continued to review documentation submitted by the licensee addressing these high-priority areas in accordance with a protocol that provides governing roles and responsibilities between the licensees and CNSC staff.

Feeders

OPG committed to confirm wall-thinning rates, by using a risk-informed method, and submitted wall-thinning assessment reports for limiting feeders. In this commitment, OPG proposed a schedule to submit these reports that would meet both its outage timelines and CNSC staff's review expectations. In March 2011, CNSC staff accepted the scope, approach and timeline for the submission of the wall-thinning assessment reports for the limiting feeders, proposed by OPG.

Days-based maintenance

OPG has initiated a project entitled "days-based maintenance" to take non-essential maintenance personnel and activities off a shift configuration. Sufficient maintenance staff will remain on shift to address emerging operational issues and emergency response.

The potential benefits of days-based maintenance include reduced handoffs and turnovers, reduced rework, and improved human performance.

A transition to days-based maintenance would allow for a significant restructuring and reduction of the minimum shift complement at each OPG NPP. This will affect nighttime staffing because non-essential maintenance activities will be performed during the day. OPG must still demonstrate that it has the resources and capability available at all times, under days-based maintenance, to cope with the most serious accidents.

2.2.3 Updates on significant regulatory issues

Alpha monitoring program

OPG developed and implemented programmatic enhancements to Darlington's alpha monitoring program based on industry best practices. Based on document reviews and an inspection conducted in October 2011, CNSC staff concluded that the program meets the requirements of the *Radiation Protection Regulations* and no significant deficiencies were identified. OPG provided a response to the corrective actions raised in the inspection report which is currently being reviewed by CNSC staff.

Response to the Fukushima Daiichi events

In March 2011, in response to the Fukushima Daiichi events in Japan, CNSC inspectors carried out reactive, focused inspections on seismic qualification/robustness, irradiated fuel bays, fire protection, backup power and hydrogen mitigation, at Darlington. Based on the inspection, CNSC staff concluded that OPG is prepared to deal with potential emergencies.

Thirty-six action items (AIs) applicable to NPPs were derived from recommendations 1 through 5 in the *CNSC Action Plan* [22] are described in appendix F, "Status of Action Items Applicable to NPPs". Licensees aim to address and finalize these actions by December 2015.

2.2.4 Early notification reports

Two ENRs were submitted for Darlington from January 2011 to April 2012. Summary details for each ENR are given in table 14. It can be seen that the ENR events had, in general, no safety significance.

Table 14: Early notification reports for Darlington

Subject	Brief description
Unit 3 manual SDS1 trip	On July 28, 2011, Unit 3 tripped while operating at full power. During routine maintenance on a shutoff rod, the odd bank of rods fell into the reactor core. SDS1 was then tripped manually as per procedure and the unit was placed in a low-power hot state. This event was caused by the incorrect installation of two wires on the power supply to the clutch of the shutoff rod, such that a short occurred when a jumper was applied before replacing the clutch control card. This released the clutches of the odd bank of rods and caused them to fall into the core. The fault had not been detected previously because the particular card had not been replaced with the unit on power.
Workplace fatality	On April 18, 2012, an OPG control technician lost consciousness and collapsed to the floor while performing work on the Unit 3 reactivity deck. A co-worker called 911 and the Darlington Nuclear Emergency Response Team responded. The person was transported to hospital via ambulance, seen by a physician and pronounced dead upon arrival. At the time of the incident Unit 3 was shut down for planned maintenance. OPG made reports to the CNSC, the Ontario Ministry of Labour and the Durham Regional Police. The town mayor was informed by OPG's public affairs staff. OPG management suspended all work at the station for the morning and addressed all site

Subject	Brief description
	staff directly. A bereavement notice was posted on OPG's intranet and external Web site. The Durham Regional Police conducted an investigation and concluded that the cause of death was not work-related.

2.3 Pickering A and Pickering B

2.3.1 Licensing

The Pickering A PROL was renewed in June 2010 for a three-year period (effective to June 30, 2013). Since renewal, the Pickering A PROL has had four amendments, three of which were made during this reporting period. The planned 2013 licence renewal will align the Pickering A PROL expiry date with that for the Pickering B PROL.

The Pickering B PROL was renewed in February 2008 for a five-year period (effective until June 30, 2013). Since renewal, the Pickering B PROL has had 17 amendments, eight of which were made during this reporting period. The Pickering B PROL has not yet been issued under the new licence format with the accompanying licence conditions handbook (LCH).

Licence amendments

The Pickering A PROL was amended three times from January 2011 to April 2012. The details are provided in table 15.

Table 15: Amendments to Pickering A power reactor operating licence

Power reactor operating licence # – Effective date	Amendment requests
04.02/2013 – June 30, 2011	A revision to eliminate the control room shift operating supervisor position.
	A revision to eliminate the requirements for an authorized nuclear operator or a supervised control panel operator in direct attendance at the control panels of Units 2 and 3, now that the controls, alarms, and indications required to support Units 2 and 3 are under the control of the Unit 1 or 4 authorized nuclear operator.
04.03/2013 – November 22, 2011	An update to the document entitled "Pickering Minimum Shift Complement".
04.04/2013 – April 24, 2012	An update to the "Pickering Minimum Shift Complement" document to remove the Volunteer Emergency Response Team and to increase the number of Emergency Response Maintainers required. An update to reference the channel and bundle power limits outlined in the Pickering NGS-A Operating Policies and Principles.

The Pickering B PROL was amended eight times from January 2011 to April 2012. The details are provided in table 16.

Table 16: Amendments to Pickering B power reactor operating licence

Power reactor operating licence # – Effective date	Amendment requests
08.12/2013 – February 07, 2011	An update to licence condition 5.2 to incorporate the revised edition of CSA N285.4, *Periodic Inspection of CANDU Nuclear Power Plant Components* (2005), including Update No. 1.
	An update to appendix B to reflect the most current revision of OPG's nuclear management system document, N-CHAR-AS-0002 R14.
08.13/2013 – March 28, 2011	An update to licence condition 3.8 to reference the current revision of the "Nuclear Management System" document. Amendment to make administrative corrections to the PROL.
08.14/2013 – May 31, 2011	An update to the document entitled "Records and Document Control".
	An update to the document entitled "Building Development Site Plan".
08.15/2013 – November 22, 2011	An update to the document entitled "Pickering Minimum Shift Complement".
	An update to the document entitled "Pickering GS Site Security Taut-Wire Fence Layout and Survey".
	An update to the document entitled "Pickering B Operating Policies and Principles".
	An update to the document entitled "Occupational Radiation Protection Action Levels for Power Reactor Operating Licences".
	An update to the document entitled "Nuclear Management System".
08.16/2013 – February 7, 2012	An update to the document entitled "Building Development Site Plan".
	An update to the document entitled "Organizational Change Control".
08.17/2013 – February 24, 2012	An update to licence condition 2.2 to change the requirements for the annual organizational chart submission.
08.18/2012 – March 29, 2012	An update to allow the use of rod-based guaranteed shutdown state.
08.19/2012 – April 24, 2012	An update to the document entitled "Pickering Minimum Shift Complement". An update to the document entitled "Pickering Nuclear Generating Station Security Report". An update to reference the document entitled "Request for Licence Amendments; Revised NSO Minimum Complement Addendum to Pickering Site Security Report, R07 and Darlington Site Security Report, R06". An update to reference the fuel bundle power limits outlined in the Pickering NGS-B Operating Policies and Principles.

Revisions to the licence conditions handbook

The Pickering A LCH was revised five times from January 2011 to April 2012 and these revisions were approved by the CNSC's Director General, Directorate of Power Reactor Regulation. The major changes made to the LCH for this station are shown in table 17.

Pickering B does not yet have an LCH.

Table 17: Changes to Pickering A licence conditions handbook

Section	Description of change	Revision type
1.3.1	Added appendix D to the list of sections that can be changed by CNSC staff.	Administrative
3.5.1	Updated the text on RD-310.	Technical
3.5.2	Updated the text on S-294.	Technical
3.7.3	Updated the text on N287.7.	Technical
3.7.3	Updated the text on N285.5.	Technical
3.10.2, 3.10.4	Updated the CVC to clarify that modifications to the DRL cannot be implemented until the Commission Tribunal approves modifications to the DRLs in the licence.	Technical
3.11.1	Updated the CVC to incorporate the Commission Tribunal's Record of Proceedings, Including Reasons for Decision, which specifies under item 209 that the Commission Tribunal expects to receive the first report on the progress related to this issue by December 2010.	Administrative
3.13.2	Updated the text on N294-09.	Technical
Appendix D.2	Added a CEDA box repair on next Unit 1 outage.	Administrative
Appendix D.2	Added a non-standard repair on next Unit 4 outage.	Administrative
3.7.2	Lengthened the time after which OPG needs to submit the final outage report from 90 to 120 days.	Technical
Appendix D.1	Added the exemptions listed in section 3.7.3 to appendix D.1.	Administrative
3.14.1	Updated section to reflect the implementation of RD-336 and the interim period granted for software updates.	Technical
3.3.1	Removed an out-of-date statement on the limits to hours of work for casual trade workers.	Administrative
3.3.2	Updated the text to reflect the current status of the station shift complement activities.	Administrative
3.4.1	Updated text to reflect the completion of the safe storage project.	Administrative
3.6.7	Updated text to reflect that compliance with design requirements was achieved in 2010 and compliance with operational requirements will be achieved by 2012.	Administrative

Section	Description of change	Revision type
3.10.1	Updated text to reflect the current status of OPG's work on fish mortality.	Administrative
3.16.3	Updated to reflect changes that were made to section 3.12.2 in revision 3.	Technical
3.7.3	Added a reference to a letter submitted describing corrections to the historical number of body-of-tube scrape channels reported in the PIP documents.	Administrative
3.2.2, A.1.3, 3.3.5,3.3.7, 5, Appendix B	Removed text that is no longer required as the Control Room Shift Operating Supervisor position has been eliminated and replaced by the Control Room Shift Supervisor position.	Administrative
3.3.3	Removed part iii of LC 3.3 of Pickering A PROL.	Administrative
3.6.5	Removed text that described the now-completed transition to CSA N285.0-08 and Update 1.	Administrative
3.5.2	Removed Probabilistic Risk Assessment Guides that do not apply to Pickering A and changed the status of N-GUID-03611-10001-R01, Volume 4 to "accepted".	Administrative
Appendix D Table D.2	Added a standing approval for a concession to carry out temporary leak suppression by the installation of leak suppression enclosures designed by an approved contractor.	Administrative
3.2.1	Added the Pickering A organizational update for 2010.	Administrative
1.3.1	Removed the limits on the sections that can be changed by CNSC staff without Commission Tribunal approval.	Technical
3.2.1	Updated text to show closure of Action Item 2009-4-17.	Administrative
3.3.2	Updated text to show progress made on minimum shift complement issue and closure of Action Item 2004-4-09.	Administrative
3.5.2	Updated to show current status of OPG's submitted PRA methodologies for Pickering A.	Administrative
3.7.3	Added references to the currently accepted Fitness for service guidelines (FFSGs) for fuel channels, pressure tubes and feeders, and life cycle management plan for fibreglass-reinforced plastic components. Updated text under N285.5-08, *Implementation Strategy*, and edited other text in CVC section for clarity and for closer alignment with generic LCH wording.	Technical

Section	Description of change	Revision type
3.8.2	Radiation protection action level table updated as per N-REP-03420-10001 R001.	Technical
3.10.1	Text under "Mitigation Measures to Reduce Fish Mortality" revised to clarify CNSC expectations.	Administrative
3.11.1	Text updated to show current status of public alerting system around Pickering NGS.	Administrative
Table A.1.3	Title modified. Updated references for OPG revised documents (for notifications received from April 16 to Aug 15, 2011) and the related specific subsections, Document Version Control, throughout the LCH.	Administrative
Appendix D table D.2	Added consents given to use FFSGs.	Administrative
3.11.1, A.2.2	Added a paragraph on public information programs.	Administrative

2.3.2 Updates on major projects and initiatives

Management of end of life

In February 2010, OPG announced that it would not pursue refurbishment of the Pickering B units but would operate Pickering A and B for a final decade (until 2020).

The life of Pickering B is bounded by the life of the pressure tubes which was initially estimated to be 210,000 equivalent full power hours (EFPH) at the time of design. Work is being undertaken by the industry to demonstrate that the reactor pressure tubes design life is, instead, at least 247,000 EFPH.

The end-of-life dates, based on the assumed design life (210,000 EFPH) and current business capacity factors, are currently projected to occur as follows for Pickering B:

- in Q2 2014 for Unit 6
- in Q1 2015 for Unit 5
- in Q2 2015 for Unit 7
- in Q2 2016 for Unit 8

To support Pickering B operation beyond the current assumed design life, OPG submitted the following documents:

- *Pickering B Integrated Implementation Plan* (IIP). This document identifies the incremental work required to operate the Pickering B units beyond the assumed pressure tube design life of 210,000 EFPH in the absence of a refurbishment.

- *Pickering B Continued Operations Plan* (COP). This document provides the framework for ensuring the improvement actions identified in the IIP. Some of the actions in this plan are to complete studies and analyses that are expected to demonstrate fitness for service for continued operation. If additional actions are required to support continued operation, these new actions will be included in the annual COP update.
- *Pickering A and B Sustainable Operations Plan* (SOP). This document describes the arrangements and activities required to demonstrate safe and reliable operation of Pickering A and B for each of the 14 SCAs until the end of commercial operations.

CNSC staff are currently finalizing the review of these documents, and can conclude that OPG has made significant progress from the original submission of the COP in 2010. Detailed discussion regarding CNSC staff assessment of these documents will be part of the next licence renewal public hearings in 2013.

Days-based maintenance
OPG has initiated a project entitled "days-based maintenance" to take non-essential maintenance personnel and activities off a shift configuration. Sufficient maintenance staff will remain on shift to address emerging operational issues and emergency response.

The potential benefits of days-based maintenance include reduced handoffs and turnovers, reduced rework, and improved human performance.

A transition to days-based maintenance would allow for a significant restructuring and reduction of the minimum shift complement at each OPG NPP. This will affect nighttime staffing because non-essential maintenance activities will be performed during the day. OPG must still demonstrate that they have the resources and capability available at all times, under days-based maintenance, to cope with the most serious accidents.

2.3.3 Updates on significant regulatory issues

Fish mortality due to impingement and entrainment
In the 2008 NPP Report, fish mortality due to impingement and entrainment was raised as a major issue.

OPG was required to reduce annual impingement mortality by 80 percent by 2012. OPG installs a barrier net in front of the water intake each year from spring to fall, inclusive. Test results from the first year, 2010, were reported in July 2011. Performance was close to the annual target of 80 percent, but was not clearly above it because of episodes in which the net was not properly held in place; these episodes were due to events of algae influx and unusually strong lake currents. New design improvements to the barrier net were implemented by July 2011. OPG will continue to monitor year-round screen house fish counts and seasonal net performance in 2011 and 2012 to determine if the new design is adequate. Because northern pike become impinged on intake screens primarily during the winter, OPG has also funded the restoration of northern pike spawning habitat in the nearby Duffins Creek Marsh.

OPG is required to use non-technology approaches to reduce entrainment mortality. Technology is not reasonably practicable due to site constraints, long installation timelines and high costs of the few proven options relative to the short time to the end of operating life for the NPP. OPG has proposed several habitat improvement projects to offset the effect of entrainment, and CNSC staff are working with OPG to determine how to resolve the issue.

Fish mortality due to thermal plume
In the 2008 NPP Report, fish mortality due to the effects of the thermal plume on round whitefish spawning was raised as a major issue.

OPG has undertaken studies to assess the effects of the thermal plume on round whitefish spawning. The studies concluded that the thermal plume from Pickering B presents a potential but small risk to round whitefish.

In early 2012, OPG completed a review of 14 potential mitigation options. Environment Canada and CNSC staff are working with OPG to determine how to resolve the issue.

Public alerting for the City of Pickering and Durham Region
The status of the public alerting system for the City of Pickering and Durham Region was discussed at two Commission Tribunal meetings during the reporting period, as the Commission Tribunal was concerned that not all provincial requirements for nuclear emergency public alerting are being met. The latest status update was provided in March 2012.

Durham Region is responsible for implementing and operating the emergency public alerting system around Pickering A and B. The requirements for emergency public alerting are described in the Provincial Nuclear Emergency Response Plan (PNERP) as follows:

- In the 3 km zone around each station there must be a public alerting system that provides a warning, within 15 minutes of initiation, to practically 100 percent of the people both indoors and outdoors.
- Within the remainder of the 10 km zone around each station, there must be a public alerting system that can provide a warning, within 15 minutes of initiation, to the population on an area-wide basis.

Durham Region currently has nine sirens for outdoor alerting and an automatic telephone dialling system for indoor alerting within the 3 km zone. However, testing in 2011 demonstrated that the outdoor siren coverage was insufficient and that additional sirens are required. In addition, tests showed that improvements are needed for the dialling system. Durham Region has communicated its action plan to the CNSC and plans to be fully compliant with the 3 km zone requirements by October 2012. Durham Region is also meeting with provincial authorities, OPG and the City of Toronto to develop a strategy for meeting the 10 km zone requirements.

CNSC staff are satisfied with the plans submitted by Durham Region for progressing towards full compliance with the PNERP and will continue to monitor progress in 2012.

Alpha monitoring program

OPG has developed and implemented enhancements to its radiation protection program to bring Pickering A and B's alpha monitoring program up to industry best practices. CNSC staff inspected the radiation protection program enhancements and concluded that the program meets the requirements of the *Radiation Protection Regulations* and no significant deficiencies were identified.

Revisions to derived release limits

OPG has revised the derived release limits (DRLs), using new dose calculations, relevant parameters and an updated model. The DRLs are the releases to the environment that will not result in the public annual dose exceeding the regulatory limit of 1 mSv. The new DRLs will be considered for incorporation by the Commission Tribunal pending a licence amendment request from OPG. The DRLs for Pickering A and B are found in appendix E, "Derived Release Limits (DRLs) for Canadian NPPs".

Response to the Fukushima Daiichi events

In March 2011, in response to the Fukushima Daiichi events in Japan, CNSC inspectors carried out reactive, focused inspections on seismic qualification/robustness, irradiated fuel bays, fire protection, backup power and hydrogen mitigation, at Pickering A and B. Based on the inspection, the CNSC staff concluded that OPG is prepared to deal with potential emergencies.

Thirty-six action items (AIs) applicable to NPPs were derived from recommendations 1 through 5 in the *CNSC Action Plan* [22] are described in appendix F, "Status of Action Items Applicable to NPPs". Licensees aim to address and finalize these actions by December 2015.

2.3.4 Early notification reports

Eleven ENRs were submitted for Pickering A and B from January 2011 to April 2012. Summary details for each ENR are given in table 18. It can be seen that the ENR events were, in general, of low or no safety significance.

Table 18: Early notification reports for Pickering A and B

Subject	Brief description
Pickering A Unit 1 tripped on high heat transport system temperature	On January 6, 2011, Unit 1 had an automatic reactor trip on the SDSA heat transport high temperature after a reduction in feedwater flow to one quadrant of boilers. The reduction in flow was caused by the closure of the large boiler level control valve, following the loss of power to the boiler level controller. The power was lost to the level controller, because a fuse opened due to a short circuit in the power supply cable of a field chart recorder, which had been pulled out of its panel for routine maintenance. The short was due to a nick in the cable. Many other devices were supplied from the same fuse, but the controller was the only consequential device affected by the loss of power.
Pickering B Unit 5 SDS2 tripped on spurious signal	On January 18, 2011, while Unit 5 Channel H was rejected (safe-stated) for regular maintenance testing, Channel J experienced a spurious trip. The trip was due to a failure of an amplifier, which resulted in a complete trip of SDS2. After the SDS2 trip, SDS1 also tripped due to the pressure in the heat transport system reading at the very low pressure setpoint.
Pickering A Unit 4 moderator spill	On February 24, 2011, a spill of moderator water inside the reactor building occurred, following a unit shutdown to investigate increased leakage of moderator water to collection. It had been observed that the leakage rate from a moderator pump to the collection system had increased substantially. OPG decided conservatively to take the unit down to investigate the cause so it was shutdown on February 24 at about 1:00 p.m. Following shutdown, indication was received of water in the moderator pump room sump, which indicated that moderator water was now spilling onto the floor. Following extensive preparation, an entry was made to the moderator pump room and the leak was isolated. Investigation revealed that the pump shaft had failed, inside the coupling that joins the motor shaft to the impeller shaft. The pump bearings and impeller seals had suffered considerable damage. The leak was isolated and there was no unplanned dose to workers.
Pickering A Unit 1 manual reactor trip from full power	On March 11, 2011, Unit 1 was manually tripped from full power. This was performed due to the following sequence. Regulating system control valve CV105 failed closed on March 7, 2011, and control was assumed by the regulating system's large control valves, with resultant coarser control of moderator level. The failure of CV105 did not have any immediate adverse consequence on unit operation while it was at steady-state full power. However, OPG decided to shut the reactor down as there was concern that the normal shutdown procedure could lead to an automatic reactor trip, because of coarser moderator level control. Therefore, the reactor was manually tripped from full power, instead of risking an automatic trip during shutdown activities.
Pickering A release of demineralized water	On March 14, 2011, approximately 73,000 L of demineralized water from the auxiliary irradiated fuel bay was released into Lake Ontario. Failure of one of the auxiliary irradiated fuel bay cooling pump seals resulted in the demineralized water leak. The amount of tritium released has been conservatively estimated at 47.3 gigabecquerels. This is well below the monthly action level of 4.1 petabecquerels, which itself is only 10 percent of the regulatory limit. The activity increase from the normal background lake tritium levels of around 6 Bq/L is estimated to be 0.56 Bq/L at the most affected water supply plant, F.J. Horgan, which is 11 km away. The activity increase at the Ajax water supply plant is estimated to be 0.007 Bq/L. These values are well below the Ontario drinking water standard of 7,000 Bq/L.

Subject	Brief description
Pickering A Unit 1 manual reactor trip from low power	On March 25, 2011, Unit 1 was manually tripped from 0.11 percent of full power after a partial loss of class IV power occurred. OPG was in the progress of starting up Unit 4 when the circuit breaker supplying one of four class IV electrical buses opened, resulting in a partial loss of class IV power. The procedure for loss of class IV power requires the reactor to be tripped. The event was reported to CNSC staff, Emergency Management Ontario and the Durham Emergency Management Office.
Pickering A and B report on security of information	On July 10, 2010, OPG submitted a confidential S-99 event report regarding a member of the public who claimed to possess classified OPG documents taken from a terrorist Web site. The RCMP determined this to be a hoax. The ENR CMD for this S-99 report was presented to the Commission Tribunal on March 31, 2011.
Pickering B Unit 5 moderator poison (gadolinium) concentration lower than expected	Unit 5 was in planned outage P1151. On March 30, 2011, the moderator was being refilled as part of the normal activities to transition from a drained guaranteed shutdown state to an over-poisoned guaranteed shutdown state. As outlined in the moderator refill procedure, chemistry sampling of the Unit 5 moderator was performed and found the Gadolinium (Gd) concentration to be less than that in the previous sample. Unit 5 moderator refill was suspended and a decision was made to return the unit to a drained guaranteed shutdown state on April 1, 2011.
Pickering A Unit 1 increased condenser vacuum pressure resulting in reactor trip	On June 19, 2011, a loss of turbine condenser vacuum on Unit 1 at Pickering led to a reactor trip on heat transport (HT) high pressure. At the start of the shift the condenser vacuum was 5.4 kPaa (absolute). During the shift the pressure started to rise slowly. At 14 kPaa the turbine unloaded automatically and an automatic reactor setback occurred, which reduced reactor power gradually from 100 percent of full power to 88 percent of full power. The condenser pressure continued to rise and operations staff manually initiated a further reactor setback. As per procedure, operations staff started the second HT pressurizing pump and manually tripped the turbine. Shortly thereafter, the reactor tripped from 46 percent of full power on HT high pressure.
Pickering B Unit 7 trip on Shutdown System 2 during channelized maintenance	On July 13, 2011, Unit 7 tripped on SDS2. The Authorized Nuclear Operator was in the process of resetting SDS2 channel "H" following maintenance on the channel. Instead of pressing the "reset" button for channel "H", he pressed the "manual trip" buttons for both channel "H" and channel "G", tripping the reactor. SDS2 uses two-out-of-three trip logic, meaning that the reactor trips if two of the three channels trip. OPG restarted the reactor after the poison outage.
Pickering A and B employee dismissals for code of conduct violations	On August 2, 2011, OPG Security was advised that some OPG employees were allegedly involved in illicit drug activities at the Pickering NGS site. OPG Security initiated an internal investigation to determine the circumstances of the allegation. Following the initial stages of the OPG investigation, a decision was made by OPG to notify Durham Regional Police Service (DRPS) of the situation. DRPS subsequently conducted their own investigation. During the course of both the DRPS and OPG investigations, there was no evidence of illegal activities within the PNGS protected area. Furthermore, there was no evidence of fitness-for-duty issues with any of the individuals identified in the allegation. OPG was subsequently advised by DRPS on September 29, 2011 that they had concluded their investigation and that no criminal charges would be laid. OPG's Human Resources department assumed responsibility for the matter. As a result, on November

Subject	Brief description
	18, 2011, 11 OPG employees were dismissed due to violations related to the OPG Code of Business Conduct.

2.4 Gentilly-2

2.4.1 Licensing

The Gentilly-2 PROL was renewed in June 2011 for a five-year period (effective to June 30, 2016). Since renewal, the Gentilly-2 PROL has had one amendment.

Licence amendments

One amendment was made from January 2011 to April 2012. Details of this amendment are provided in table 19.

Table 19: Gentilly-2 power reactor operating licence amendments

Power reactor operating licence # – Effective date	Amendment request
10.01/2016 – February 7, 2012	Update two values of the derived release limits.

Revisions to the licence conditions handbook

The Gentilly-2 LCH has been revised once since its implementation; this revision was approved by the CNSC's Director General of the Directorate of Power Reactor Regulation. The most important changes made to the LCH for this station from January 2011 to April 2012 are shown in table 20.

Table 20: Changes to Gentilly-2 licence conditions handbook

Section	Description of change	Revision type
3.1.3; 3.6.2; 3.11.2; Appendix A.3	Change made to the revision number of MG-22-08 (rev. 1.2).	Administrative
3.3.6; Appendix A.3	Change made to the revision number of the certification examination management manuals GEA-1 and GEA-2 (rev. 1.1).	Administrative
3.4.2; 3.12.2; Appendix A.1	French titles of CSA standards N290.15 and N294 inserted.	Administrative
3.5.1; Appendix A.3	CSA change made to the Safety Report revision number (rev. 2011).	Administrative
3.6.5	CSA standard N285.0, revision 1995 added.	Administrative
3.7.3	Change made to the implementation date of CSA standards N285.4-2005 and N285.5-2008 (March 31, 2012).	Administrative
Appendix F	Change made to table H15 in appendix F.	Administrative
Appendix G	Appendix G: Regulatory Plan was deleted.	Administrative
Appendix A.1	CSA standard N292.3 added to appendix A.1	Administrative
3.4.2; 3.4.5;	Change made to the revision number of the OP&Ps (rev. 7).	Administrative

Section	Description of change	Revision type
Appendix A.3		
3.11.1	A paragraph on the public information program was added to the compliance verification criteria.	Administrative
All	Grammatical and spelling corrections.	Administrative
Flyleaf heading	Change made to the operating licence number.	Administrative

2.4.2 Updates on major projects and initiatives

Regulatory plan

A relicensing hearing was held for Gentilly-2 in 2011. CNSC staff reviewed the operation plan submitted by Hydro-Québec and developed a regulatory plan outlining the regulatory licensing and compliance review measures for the period leading up to refurbishment or the end of operation. This regulatory plan can be found in the LCH.

Hydro-Québec staff made noticeable efforts to address the open action items found in the CMD for the relicensing hearing, CMD-H15. Most of the action items were closed and the licensee is continuing with the transition plans, as given in the LCH, for the remaining open action items.

Refurbishment project

CNSC staff continued to review refurbishment project documents submitted by Hydro-Québec on the integrated safety review (ISR) required as per regulatory document RD-360, *Life Extension of Nuclear Power Plants* [24].

CNSC staff reviewed the responses from Hydro-Québec to comments made on the ISR basis document. The majority of the responses were found to be acceptable and CNSC staff closed the action item related to this review. The outstanding issues will be addressed during the review of the safety factor reports (SFRs), the global assessment report (GAR) and the integrated implementation plan (IIP).

CNSC staff completed the preliminary review of the SFRs and concluded that additional information was needed. Hydro-Québec reviewed the comments from the CNSC and submitted a proposal on the standards to be used for the ISR.

CNSC staff completed the initial review of the GAR, including the IIP, and concluded that this document requires revision to bring it up-to-date and to address the CNSC comments on it and the SFRs. Hydro-Québec plans to submit the revised GAR, including the IIP, before the end of June 2012.

2.4.3 Updates on significant regulatory issues

Hold points

In accordance with its operating licence, Hydro-Québec was required to conduct certain inspections and perform repairs in order to have the hold points indicated in the LCH lifted. CNSC staff reviewed these hold points and authorized Hydro-Québec to restart the plant.

Announcement of refurbishment project

As of the end of the reporting period, Hydro-Québec had not yet received a final response from the Québec government regarding approval of the Gentilly-2 refurbishment project.

Effects of thermal plume, impingement and entrainment

In November 2010, Hydro-Québec revised its action plan on the issue of fish impingement at the water intake channel and the effects of the thermal plume outfalls at Gentilly-2. This revised plan was submitted to the CNSC in February 2011.

During 2011, Hydro-Québec submitted the results of two effects of thermal plume studies. The first focused on the effects of water temperature on fish sexual maturity and the second was a water temperature monitoring validation outside the area of impact of the warm water outfalls. The CNSC and Environment Canada are reviewing the results of these two studies. Depending on the outcome of these reviews, additional studies may be required.

In December 2011, Hydro-Québec also submitted the results of an evaluation of the analysis of solutions to the entrainment of debris and fish at the water intake channel. The results are being reviewed by the CNSC and Fisheries and Oceans Canada.

Alpha monitoring program

Hydro-Québec continued to implement long-term radiation protection program enhancements to monitor and control alpha hazards and to align the program with industry best practices. Protective and control measures are in place to protect workers from alpha radiation hazards.

CNSC staff continued to monitor Gentilly-2's long-term radiation protection program enhancements related to alpha monitoring and control. Full implementation of these enhancements is scheduled to be completed at Gentilly-2 by the end of 2012.

Response to the Fukushima Daiichi events

In March 2011, in response to the Fukushima Daiichi events in Japan, CNSC inspectors carried out reactive, focused inspections on seismic qualification/robustness, irradiated fuel bays, fire protection, backup power and hydrogen mitigation, at Gentilly-2. Based on the inspection, CNSC staff concluded that Hydro-Québec is prepared to deal with potential emergencies.

Thirty-six action items (AIs) applicable to NPPs were derived from recommendations 1 through 5 in the *CNSC Action Plan* [22] are described in appendix F, "Status of Action Items Applicable to NPPs". Licensees aim to address and finalize these actions by December 2015.

2.4.4 Early notification reports

Two ENRs were submitted for Gentilly-2 from January 2011 to April 2012. Summary details for each ENR are given in table 21. It can be seen that the ENR events had, in general, low safety significance.

Table 21: Early notification reports for Gentilly-2

Subject	Brief description
Heavy water leak to the heat transport collection system	On June 13, 2011, a water leak into the coolant collection (3381-TK1) was confirmed. At 8:21 a.m., an area alert was declared due to radiation risk in the reactor building. The emergency center was activated. Coolant water was found on the floor of room R2-006, located in the basement. This water came from a small leak on a sight glass (3381-SG7), which is part of the collection system. Operators wearing plastic protective clothing were sent to a few rooms of the reactor building to investigate the leak. The level of tritium releases reached 0.5 percent of the DRL for tritium, which is 1.7×10^{15} Bq per week. It was determined that the operators investigating the leak received a low dose of less than 0.03 mSv.
Heavy water leak in the reactor building	On the morning of April 26, 2012, work was under way to change a plug in a fuelling machine. The level of atmospheric tritium measured in the reactor building increased. An area alert was declared and emergency procedure PU-100 was implemented and the reactor building was evacuated. Two operators stopped the leak and evacuated. A team was sent into the reactor building and recovered the heavy water spilled on the floor (10 L) and in a vent line (60 L). The end of the alert was declared at noon. The two operators involved in stopping the leak were exposed to low tritium doses (0.02 and 0.03 mSv) during this event. The release of tritium was estimated to be 1.85×10^{12} Bq, approximately 0.11 percent of the DRL. This tritium release was well below regulatory limits.

2.5 Point Lepreau

2.5.1 Licensing

In 2010, NB Power requested a renewal of the licence, which was scheduled to end on June 30, 2011, for a one-year period due to the technical issues delaying the refurbishment. In April 2011, the Commission Tribunal renewed the Point Lepreau licence, effective until June 30, 2012.

In June 2011, NB Power made a request to renew Point Lepreau's PROL for a period of five years. NB Power requested the hearing on this matter to be held in the fall of 2011, in conjunction with its fuel reload and reactor restart request to the Commission Tribunal. This licensing renewal was heard by the Commission Tribunal via public hearings in October and December, 2011.

In February 2012, the Point Lepreau PROL 17.00/2017 was renewed for a five-year period (effective until June 30, 2017).

In the same hearing, the Commission Tribunal granted NB Power permission to proceed with fuel reload and restart of the reactor post refurbishment.

Licence amendments

The former Point Lepreau operating licence PROL 17.00/2012 was amended once during the period July 1, 2011 to February 17, 2012. Details are provided in table 22.

The current Point Lepreau operating licence PROL 17.00/2017 has not been amended since its effective date of February 17, 2012.

Table 22: Point Lepreau power reactor operating licence amendments

Power reactor operating licence # – Effective date	Amendment requests
17.01/2012 – August 26, 2011	Update NB Power document RD-01364-L25, *Station Security Report* to Revision 12 in appendix B.
	Update NB Power document NMM-00660, *Nuclear Management Manual* to Revision 6 in appendix B.
	Delete Licence Condition 13.8 and removal of the J.L. Shepherd 492 Beta Calibrator (Item 9) from appendix H: Nuclear Substances and Prescribed Equipment.
	Update NB Power document *Point Lepreau Nuclear Generating Station Safety Report* to 2009 Edition in appendix A.

Revisions to the licence conditions handbook

No revisions were made to the Point Lepreau LCH during the reporting period.

2.5.2 Updates on major projects and initiatives

Seismic qualification
The Commission Tribunal required in its decision for renewing the Point Lepreau PROL that NB Power complete a site-specific seismic hazard assessment and share the results of this assessment through its public information program. NB Power followed up by submitting an assessment plan as a part of its response to the *CNSC Action Plan* [22]. CNSC staff reviewed this plan and agree with the proposed submission of the initial seismic hazard assessment by the end of 2012.

Environmental monitoring
During the Point Lepreau licence renewal hearings, an intervention by Fundy Baykeeper requested that NB Power sample intake water at Point Lepreau for fish eggs, larvae, zooplankton and phytoplankton. CNSC staff support this request and recommend that this monitoring be undertaken. CNSC staff and Department of Fisheries and Oceans staff will be conducting a site visit in 2012 to discuss a path forward with NB Power. Updates on this issue will be included in the 2012 NPP Report.

CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [25], was revised in 2010 to include radioactive and hazardous substances, physical stressors, potential biological effects, and pathways for both human and non-human biota. Discussions are underway between CNSC staff and the industry on adding these requirements to the CNSC regulatory framework for major facilities. Therefore, CNSC staff have recommended that NB Power conduct a gap analysis and submit an implementation plan for complying with this standard.

Point Lepreau refurbishment project
NB Power originally started the reactor refurbishment in 2008 and planned to return the reactor to full power by 2009. Due to technical issues the refurbishment project was extended. As of the end of the reporting period, NB Power plans to return the reactor to full power by fall 2012.

Some of the major construction activities carried out in this refurbishment project included:

- replacement of all 380 fuel channel assemblies, calandria tubes, and connecting inlet and outlet feeder piping from the end fittings back to the headers (retube)
- upgrades to the main generator
- modifications to the calandria vault overpressure and end shield cooling
- addition of a filtering system to the main control room ventilation system

- installation of new programmable digital comparator units on the shutdown systems
- improvements to trip coverage
- installation of passive autocatalytic recombiners to mitigate hydrogen buildup during severe accidents
- installation of an emergency filter vent system and calandria vault makeup line to improve containment performance in the event of a severe accident
- replacement of obsolete components and equipment
- implementation of environmental qualification upgrades
- installation of fire protection upgrades
- installation of seismic modifications

During 2011, NB Power completed the installation of calandria tubes, pressure tubes, and upper feeder pipes, and refilled the main moderator system. The lower feeder installations were completed in February 2012.

The current PROL includes licence conditions that are directly related to the Point Lepreau refurbishment project. These licence conditions require the licensee to obtain Commission Tribunal approval before reloading fuel into the reactor core and proceeding with reactor restart. CNSC approval is required at the following hold points:

- prior to refuelling of the reactor
- prior to releasing the reactor guaranteed shutdown state
- prior to exceeding 0.1 percent reactor power
- prior to exceeding 35 percent reactor power

In February 2012, the Commission Tribunal granted NB Power permission to proceed with fuel reload and restart of the reactor. Fuel reload was completed in early April 2012.

2.5.3 Updates on significant regulatory issues

Emergency response team improvements

In 2010, the fire protection and response specific area of the emergency management and fire protection SCA was rated "below expectations" due to a Type II inspection on the emergency response team (ERT). In August 2011, CNSC staff and NB Power signed a protocol indicating what key activities NB Power needs to undertake to demonstrate the acceptability of its fire protection and response program and obtain a "satisfactory" rating. CNSC staff recognized that there were significant improvements to the ERT performance in the later part of 2011 and, as a consequence, NB Power reached the required "satisfactory" rating near the end of 2011.

Fire protection

CNSC staff are satisfied with NB Power's *Fire protection improvement plan*, which was developed to implement the requirements of N293-07 [9]. CNSC staff are also satisfied with NB Power's compensatory measures to meet the intent of the new codes and standards; however, implementation of the fire protection program must be further developed and physical upgrades are required for full compliance. All of the proposed compensatory measures must be in place before the restart of the reactor, as required by the Point Lepreau PROL and LCH, under licence condition 16.4. NB Power must comply with the latest fire protection codes and standards by December 31, 2014.

Alpha monitoring program

In August 2010, CNSC staff presented its expectations and acceptance criteria for implementation of the radiation protection program for enhanced alpha monitoring based on industry best practice and operating experience.

In December 2010, CNSC staff concluded that NB Power had implemented sufficient measures to protect workers against alpha hazards and demonstrated a commitment to implementing radiation protection program enhancements to monitor and control alpha hazards. During 2011, NB Power continued to implement these enhancements to the satisfaction of CNSC staff.

2012 Point Lepreau emergency exercise

NB Power completed a major emergency exercise in March 2012. The exercise included offsite activation of the provincial emergency centre and a limited activation of the CNSC Emergency Operations Centre. As of the end of the reporting period, the results of the exercise were not known; however, they will be reported to the Commission Tribunal during the public presentation of this report or in the 2012 NPP Report.

Response to the Fukushima Daiichi events

In March 2011, in response to the Fukushima Daiichi events in Japan, CNSC inspectors carried out reactive, focused inspections on seismic qualification/robustness, irradiated fuel bays, fire protection, backup power and hydrogen mitigation, at Point Lepreau. Based on the inspection, CNSC staff concluded that NB Power is prepared to deal with potential emergencies.

Thirty-six action items (AIs) applicable to NPPs were derived from recommendations 1 through 5 in the *CNSC Action Plan* [22] are described in appendix F, "Status of Action Items Applicable to NPPs". Licensees aim to address and finalize these actions by December 2015.

2.5.4 Early notification reports

One ENR was submitted for Point Lepreau from January 2011 to April 2012. Summary details for this ENR are given in table 23. It can be seen that the ENR event had, in general, no safety significance.

Table 23: Early notification reports for Point Lepreau

Subject	Brief description
Small spill of heavy water	On December 13, 2011, while conducting moderator refill activities, approximately 4 to 6 litres of heavy water from the moderator system leaked from the Gas Chromatograph located within the reactor building. As per Point Lepreau Generating Station (PLGS) procedure a radiation alert was promptly initiated and workers were directed to leave the reactor building and provide bioassay samples. The small amount of heavy water was cleaned up (the water was recovered) and a ventilated tent was established around this area to minimize the spread of tritium vapour. Releases to the environment were less than 3 percent of the station action level (8.2×10^{14} Bq per week).

Part 3 – Actions Resulting from the Fukushima Daiichi Nuclear Accident

Introduction

On March 11, 2011, a magnitude 9.0 earthquake, followed by a devastating tsunami, struck Japan. The combined impact of the earthquake and tsunami on the Fukushima Daiichi nuclear power plant caused a severe nuclear accident. In the days that followed, due to the loss of electrical power leading to the loss of cooling capability, three of the station's six reactors (operated by the Tokyo Electric Power Company (TEPCO)) overheated, sustained core meltdowns, hydrogen explosions and fires leading to the uncontrolled release of radioactive material. As a result of this nuclear accident, the international community, particularly countries with operating nuclear power plants undertook a review of the safety of operating NPPs, their emergency preparedness and response, and their regulatory framework and oversight processes.

Safety reviews of NPPs

The CNSC launched a review of NPP facilities in Canada in April 2011 to confirm their ability to withstand external events, such as large earthquakes and floods. The CNSC first directed licensees to review initial lessons learned from Fukushima, re-examine the safety cases of NPPs, and report on implementation plans for short-term and long-term measures to address any significant gaps. The CNSC then established the CNSC Fukushima Task Force (Task Force) to evaluate the implications of the Fukushima nuclear accident on NPPs and to review the licensees' submissions. The Task Force documented its findings, which can be categorized into four groups:

- defence in depth
- emergency preparedness
- regulatory framework and processes
- international co-operation

Based on the *CNSC Fukushima Task Force Report* [26], the CNSC created the comprehensive *CNSC Action Plan* [22] to apply the lessons learned to the safe operation of NPPs. This action plan identified specific deliverables to be completed by the end of 2015, including measures to prevent and mitigate impacts from "beyond-design-basis accidents", which are of very low probability but have potentially high consequences. This action plan has been subject to public consultation, a peer review by an International Atomic Energy Agency (IAEA) Integrated Regulatory Review Service (IRRS) panel of experts and an independent review by an external advisory committee (EAC) [27] mandated by the President of the CNSC to assess the organization's processes and responses to the accident.

In responding to the lessons learned from the Fukushima Daiichi nuclear accident, NPP licensees clearly demonstrated their continued commitment to safety and took immediate action to confirm the robustness of their NPPs. Guided by the Task Force's safety review criteria [28], they initiated improvements that will further enhance safety and accelerated others that were already in progress. The licensees have participated in national and international activities and are taking concrete steps, individually and collectively, to address findings. In addition, most licensees have already implemented significant safety upgrades, as part of refurbishment activities. These upgrades were identified through integrated safety reviews that were conducted against modern standards and practices, and they have been proven to be beneficial during the Fukushima crisis.

Summary of findings

Summarized below are the findings of the post-Fukushima review and the actions that both licensees and the CNSC are pursuing to further enhance the safety of NPPs and reduce the risks associated with their operation.

External events – The CNSC review reconfirmed the robustness of NPPs to withstand large external hazards. Conditions taken into consideration at the time of design are site specific, but generally include extreme weather conditions, floods, earthquakes and explosions. All NPPs are located far from tectonic plate boundaries, making the risk due to a major earthquake, and consequent tsunami, negligible. As part of the *CNSC Action Plan* [22], NPP operators are conducting comprehensive reassessments of site-specific external hazards by using modern tools, including probabilistic safety assessments. Although gaps are not expected, any that would pose a risk to safety will be addressed promptly.

Design issues – The designs of CANDU reactors include several features that prevent accidents and can help mitigate impacts should an accident occur. They have a large inventory of cool water surrounding the fuel, capable of providing passive cooling, such that adequate time is available for long-term mitigation of accidents. Also, CANDUs have two groups of independent, physically separated, and diverse backup power and cooling water systems. Thus, adequate time would be available for long-term mitigation of a beyond-design-basis accident. This conclusion also applies to irradiated fuel bays, which were assessed to be seismically robust with diverse means available for adding water. Although the risk of an accident is very low, NPP operators are implementing several modifications to improve their stations' ability to withstand a prolonged loss of power and other challenges such as the loss of all heat sinks. These modifications include portable equipment, emergency containment filtered vent systems, passive hydrogen recombiners, and water make-up provisions. The CNSC is taking action and revising regulatory requirements, including those for the design of new NPPs.

Severe accident management (onsite) – Adequate provisions for severe accident management (SAM) and recovery are in place at all NPP sites. SAM guidelines have been largely implemented at all plants except for Gentilly-2, which will be shutdown later in 2012 for an extended outage. SAM guidelines implementation will be a prerequisite for the Gentilly-2 restart. All licensees reviewed their procedural guidance and design capabilities to cope with accidents, including those involving significant core damage. The *CNSC Action Plan* [22] nevertheless identified a number of enhancements, which are currently being pursued by licensees. In the short term, licensees are acquiring emergency equipment, such as portable pumps and generators, to be stored onsite and offsite, to ensure reactors can be brought to a safe shutdown state in any credible accident scenario.

Industry is working on modelling enhancements for beyond-design-basis accidents, including for multi-unit NPPs. The CNSC will also be making changes to its regulatory framework to reflect the need for SAM programs.

Emergency preparedness (offsite) – In its review, the CNSC confirmed that emergency preparedness and response measures remain adequate. Nonetheless, in order to see where improvements could be made, the CNSC called for a review of emergency plans and capabilities to respond effectively in a severe event and/or multi-unit accident. The conduct of regular and challenging large-scale drills has been one of the key measures identified in the *CNSC Action Plan* [22]. Provincial agencies, which have the lead for offsite emergency preparedness, are participating in this review. Both Public Safety Canada and Health Canada are reviewing the national-level oversight of offsite nuclear emergency plans, programs and performance. Licensees are also working on improvements to offsite emergency preparedness, related to such areas as severe events, source term estimation, dose modelling and radiation monitoring. The CNSC is also preparing amendments to, among others, the *Class I Nuclear Facilities Regulations* to require submission of applicable offsite emergency plans, and to the *Radiation Protection Regulations* to further clarify emergency dose limits.

International co-operation – The CNSC has memoranda of understanding in place with most international stakeholders and also chairs the CANDU Senior Regulators' Meeting. The CNSC also has excellent working relationships with the United States for the exchange of nuclear regulatory and emergency preparedness expertise. NPP licensees are involved in various international groups with a focus on nuclear safety, including the CANDU Owners Group and the World Association of Nuclear Operators. The CNSC and the nuclear power industry are active participants in the activities of the International Atomic Energy Agency and fully support the IRRS program and missions.

Implementation of the *CNSC Action Plan*

The *CNSC Action Plan* [22] is based on the findings and recommendations of the Task Force which led to the development of specific actions on licensees and the CNSC to strengthen defence in depth, enhance emergency response, improve the regulatory framework and enhance international collaboration. The action plan was presented to the Commission Tribunal for acceptance at a public meeting held on May 3, 2012. Consistent with the *CNSC Management Response to CNSC Fukushima Task Force Recommendations* [29], the *CNSC Action Plan* [22] will be implemented in the short-term, medium-term and long-term timeframe.

Table 24 shows a subset of the *CNSC Action Plan* [22] pertaining to the actions required of licensees to address the gaps identified by the Task Force. Specific actions stemming from recommendations 1 through 5, which are directly applicable to licensees, were initiated on February 17, 2012, by the CNSC through the creation of several site-specific action items. These are described in appendix F, "Status of Action Items Applicable to NPPs".

Table 24: Task Force recommendations applicable to nuclear power plants

Task force recommendations	Implementation timeline		
	Short term (Dec 2012)	Medium term (Dec 2013)	Long term (Dec 2015)
Strengthening reactor defence in depth			
1. Verify robustness of NPP designs	✓	✓	✓
2. Assessment of site-specific external hazards		✓	
3. Enhance modelling capabilities		✓	
Enhancing emergency response			
4. Assess emergency plans (onsite)	✓		
5. Update emergency facilities and equipment	✓		

Next steps

The actions placed on licensees, to date, will be revised and updated to reflect the outcome of the Commission Tribunal deliberations, expected later in June 2012, and any amendments that the Commission Tribunal may direct as part of its decision.

The status of the NPP action items depicted in appendix F reflects the state of work completed as of May 31, 2012, which essentially remains unchanged from what was presented to the Commission Tribunal on May 3, 2012, in the *CNSC Action Plan* [22].

CNSC staff will be providing an additional update to the Commission Tribunal on the status of the NPP action items, as of July 31, 2012, in a supplemental CMD for the August 15, 2012, public meeting.

Conclusion

The overarching conclusion of the Task Force review is that NPPs in Canada are safe and the risk posed to the health and safety of Canadians or to the environment is very low. Additional safety improvements have been systematically identified to address the lessons learned from Fukushima. These improvements, when completed by both the licensees and the CNSC, will render NPPs in Canada even safer, reducing the associated risk to as low as reasonably practicable.

Part 4 – Summary and Conclusions

This report summarizes CNSC staff's assessment of the safety performance of NPP licensees and of the nuclear power industry as a whole in 2011. The assessment is conducted by first rating the performance of each licensee individually and then aggregating the results to give the industry performance for each of the 14 safety and control areas (SCAs) in the assessment framework. The report also discusses generic issues, identifies industry trends and compares Canadian nuclear power industry safety performance indicators with those of international NPP operators and other industries.

The 2011 NPP Report includes a brief summary of actions taken by licensees in Canada in response to the TEPCO Fukushima Daiichi nuclear accident to confirm that NPPs are safe, to identify measures to further enhance the safety of NPPs in Canada, and to reduce the associated risks to as low as reasonably practicable.

4.1 Safety performance of NPPs in Canada

CNSC staff concluded that the nuclear power industry operated safely in 2011. The review of each licensee's safety performance in the 14 SCAs confirms that the licensees made adequate provisions to protect the health and safety of Canadians and the environment, as well as to ensure that Canada continued to meet its international obligations on the peaceful use of nuclear energy. These conclusions are based on the following observations:

- There were no serious process failures at the NPPs.
- No member of the public received a radiation dose that exceeded the regulatory limit.
- No worker at any NPP received a radiation dose that exceeded the regulatory limits.
- The frequency and severity of injuries/accidents involving workers were minimal.
- No radiological releases from the stations exceeded the regulatory limits.
- Licensees complied with their licence conditions concerning Canada's international obligations.

The NPP operational events that occurred in 2011 had minimal impact on health, safety, the environment and Canada's international obligations. Licensees reported events requiring regulatory oversight to the CNSC and conducted (or are conducting) appropriate follow-up, which could include root-cause analysis and corrective actions, if needed.

The 2011 ratings for the SCAs and the integrated plant ratings are presented in table 25 for all NPPs, along with the industry averages. As can be seen, the integrated plant rating was "fully satisfactory" for Darlington while the ratings were "satisfactory" for the remaining NPPs. The results of the integrated plant ratings for 2011 were unchanged from the previous year.

Table 25: Canadian nuclear power plant safety performance ratings for 2011

Safety and control area	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Management system	SA	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	FS	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	FS	SA	SA	SA	SA	SA
Radiation protection	SA	SA	FS	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA	SA	SA	SA
Security	FS	FS	SA	SA	SA	SA	SA	SA
Safeguards	SA	SA	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	SA	SA	FS	SA	SA	SA	SA	SA

Within the industry, Darlington received four "fully satisfactory" safety performance ratings, in (i) operating performance, (ii) fitness for service, (iii) radiation protection, and (iv) conventional health and safety. Bruce A and Bruce B each received two "fully satisfactory" safety performance ratings, in (i) conventional health and safety, and (ii) security. The remaining SCA ratings were "satisfactory". In 2011, CNSC staff noted that no SCA received a "below expectations" rating. This is an improvement from 2010 when two stations received "below expectations" rating, namely Bruce A in radiation protection and Point Lepreau in emergency management and fire protection.

The industry average ratings were "satisfactory" for all SCAs and for the industry integrated plant rating, indicating Canadian nuclear power plants implemented effective safety and control measures and complied with regulatory requirements during 2011. For any deficiencies that were identified as part of the assessment of the SCAs, CNSC staff determined that the licensees are taking appropriate actions to address the relevant issues or deviations.

4.2 Response to the Fukushima Daiichi nuclear accident

In response to the 2011 Fukushima Daiichi nuclear accident, Canadian NPP licensees have taken specific measures to confirm and, where necessary, strengthen the safety cases of operating NPPs.

Based on the review of these measures, the CNSC Task Force concluded that NPPs in Canada are safe and the risk posed to the health and safety of Canadians or to the environment continues to be very low. Additional safety improvements have been systematically identified and, when their implementation is completed, these improvements will render NPPs in Canada even safer, reducing the associated risk to as low as reasonably practicable.

Appendix A: Definitions of Safety and Control Areas

The CNSC evaluates how well licensees meet regulatory requirements and CNSC expectations for the performance of programs in 14 safety and control areas (SCAs) that are grouped according to their functional areas of management, facility and equipment, or core control processes. These SCAs are further divided into 69 specific areas that define the key components of the SCA. The functional areas, SCAs and specific areas that are used in CNSC safety performance evaluations are given in table A.1.

Table A.1: The CNSC's functional areas, safety and control areas and specific areas for assessing licensee safety performance

Functional area	Safety and control area (SCA)	Specific area
Management	Management system	Management system (including safety management/quality management oversight)
		Organization
		Organizational/change management
		Internal communications
		Monitoring and review of safety management performance
		Safety culture
	Human performance management	Personnel training
		Personnel certification
		Certification examination and requalification testing
		Work organization and job design
		Human performance programs
		Procedures and job aids
		Fitness for duty
	Operating performance	Conduct of licensed activities
		Outage management performance
		Adequacy of procedures
		Operating experience
		Reporting and trending

Functional area	Safety and control area (SCA)	Specific area
Facility and equipment	Safety analysis	Deterministic safety analysis
		Robustness analysis for malevolent acts
		Safe operating envelope
		Criticality safety
		Probabilistic safety analysis
	Physical design	Component design
		Equipment qualification
		System design and classification (including fire protection design)
		Configuration management
		Human factors in design
		Robustness design
		Engineering change control
		Site characterization
	Fitness for service	Maintenance activities
		Structures, systems and components (SSCs) monitoring
		Equipment fitness for service / equipment performance
		Maintenance work
		Spare parts and procurement
		Identification of systems important to safety
		Specifications of parameters for systems important to safety
		Informing of maintenance program
		Assessment of reliability for systems important to safety
		Periodic inspection of pressure boundary components
		Lifecycle management
		Inspections for balance-of-plant
		Pressure boundary integrity
Core control processes	Radiation protection	Application of ALARA principle
		Personnel dosimetry
		Contamination control
		Worker dose control
	Conventional health and safety	Compliance with applicable labour codes
		Housekeeping/management of hazards
		Accident severity / accident frequency
	Environmental protection	Environmental management system
		Estimated dose to public
		Environmental risk assessment
		Effluent and emissions control (releases)

Functional area	Safety and control area (SCA)	Specific area
		Environmental monitoring
Core control processes (cont'd)	Emergency management and fire protection	Nuclear emergency management
		Conventional emergency response
		Business continuity
		Fire protection and response
	Waste management	Waste minimization, segregation and characterization
		Waste storage and processing
		Decommissioning plans
	Security	Facilities and equipment
		Access control
		Training, exercises and drills
		Nuclear response force
	Safeguards	Safeguards
	Packaging and transport	Packaging and transport

Definitions, specific areas and performance objectives for each SCA are provided below.

1. Management system

The management system SCA covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.

Performance objectives

There is an effective management system that integrates provisions to address all regulatory and other requirements to enable the licensee to achieve its safety objectives, continuously monitor its performance against those objectives, and maintain a healthy safety culture.

2. Human performance management

The human performance management SCA covers activities that enable effective human performance through the development and implementation of processes that ensure that licensees have sufficient staff in all relevant job areas with the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.

Performance objectives

Licensee staff are sufficient in number in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.

3. Operating performance

The operating performance SCA includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.

Performance objectives
Plant operation is safe and secure, with adequate regard for health, safety, security, radiation and environmental protection, and international obligations.

4. Safety analysis

The safety analysis SCA includes maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventive measures and strategies in reducing the effects of such hazards.

Performance objectives
There is demonstration of the acceptability of the consequences of design-basis events, and protective systems can adequately control power, cool the fuel and contain any radioactivity that could be released from the plant.

5. Physical design

The physical design SCA relates to activities that affect the ability of structures, systems and components (SSCs) to meet and maintain their design basis, given new information arising over time and taking changes in the external environment into account.

Performance objectives
There is confirmation that structures, systems and components that are important to nuclear safety and security continue to meet their design basis in all operational states until the end of their design life.

6. Fitness for service

The fitness for service SCA covers activities that affect the physical condition of structures, systems and components (SSCs) to ensure that they remain effective over time. This includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.

Performance objectives
Structures, systems and components, the performance of which may affect safety or security, remain available, reliable and effective, and consistent with the design, analysis, and quality control measures.

7. Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure that contamination and radiation doses received are monitored and controlled.

Performance objectives

The health and safety of persons inside the facility are protected through the implementation of a radiation protection program that ensures that occupational exposures are below regulatory dose limits and are optimized and maintained as low as reasonably achievable (ALARA).

8. Conventional health and safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

Performance objectives

Conventional health and safety work practices and conditions achieve a high degree of personnel safety.

9. Environmental protection

The environmental protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.

Performance objectives

The environment and the health and safety of persons are protected by the licensee taking all reasonable precautions, including identifying, controlling and monitoring the release of nuclear substances and hazardous substances to the environment.

10. Emergency management and fire protection

The emergency management and fire protection SCA covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions including any results of exercise participation. This also includes conventional emergency and fire response. This SCA includes the fire response rating while fire protection operations, design and analysis are discussed and rated in the appropriate SCA of operating performance, safety analysis or physical design.

Performance objectives

Adequate provisions are made for preparedness and response capability that would mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security.

A comprehensive fire protection program is implemented to minimize the risk to the health and safety of persons and to the environment from fire, through appropriate fire protection system design, fire safety analysis, fire safe operation and fire prevention.

11. Waste management

The waste management SCA covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This also covers the planning for decommissioning.

Performance objectives

There is full development, implementation and auditing of a facility- and waste stream-specific waste management program to control and minimize the volume of nuclear waste generated by the licensed activity; waste management is included as a key component of the licensee's corporate and safety culture; and a decommissioning plan is maintained.

12. Security

The security SCA covers the programs required to implement and support the security requirements stipulated in the regulations, in their licence, in orders, or in expectations for their facility or activity.

Performance objectives

Loss, theft or sabotage of nuclear material or sabotage of the licensed facility are prevented.

13. Safeguards

The safeguards SCA covers the programs required for the successful implementation of the obligations arising from the Canada/IAEA Safeguards Agreement.

Performance objectives

The licensee conforms with measures required by the facility to meet Canada's international safeguards obligations through:

- *timely provision of accurate reports and information*
- *provision of access and assistance to IAEA inspectors for verification activities*
- *submission of annual operational information and accurate design information on plant structures, processes and procedures*
- *development and satisfactory implementation of appropriate facility safeguards procedures*
- *demonstration of capability, as confirmed through CNSC onsite evaluations, to meet all requirements in support of physical inventory verifications of nuclear material by the IAEA*

14. Packaging and transport

The packaging and transport SCA covers the safe packaging and transport of nuclear substances and radiation devices to and from the licensed facility.

Performance objectives

All shipments leaving the site adhere to the Packaging and Transport of Nuclear Substances Regulations *and the* Transportation of Dangerous Goods Regulations.

Appendix B: Rating Methodology and Definitions

Performance ratings used in this report are defined as follows:

Fully satisfactory (FS)
Safety and control measures implemented by the licensee are highly effective. In addition, compliance with regulatory requirements is fully satisfactory and compliance within the SCA or specific area exceeds requirements and CNSC expectations. Overall, compliance is stable or improving, and any problems or issues that arise are promptly addressed.

Satisfactory (SA)
Safety and control measures implemented by the licensee are sufficiently effective. In addition, compliance with regulatory requirements is satisfactory. Compliance within the area meets requirements and CNSC expectations. Any deviation is minor, and any issues are considered to pose a low risk to the achievement of regulatory objectives and CNSC expectations. Appropriate improvements are planned.

Below expectations (BE)
Safety and control measures implemented by the licensee are marginally ineffective. In addition, compliance with regulatory requirements falls below expectations. Compliance within the area deviates from requirements or CNSC expectations to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee is taking appropriate corrective action.

Unacceptable (UA)
Safety and control measures implemented by the licensee are significantly ineffective. In addition, compliance with regulatory requirements is unacceptable and is seriously compromised. Compliance within the overall area is significantly below requirements or CNSC expectations, or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken, and no alternative plan of action has been provided. Immediate action is required.

Rating methodology

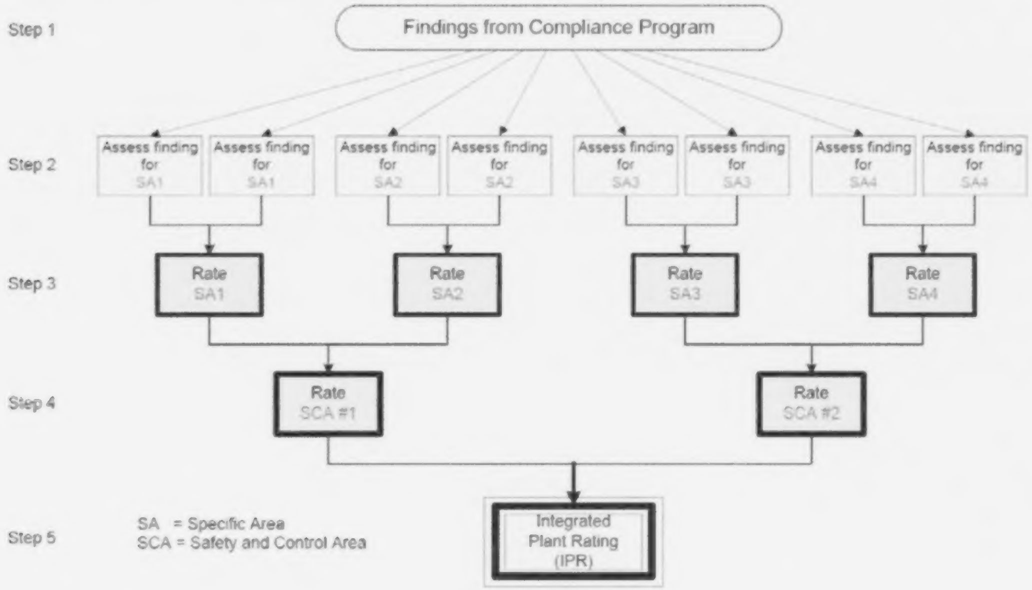
The determination of the integrated plant rating (IPR) begins with an assessment of the specific areas and determination of the rating for each one. Specific area ratings for each of the stations are based on considerations of individual findings from inspections, event reports and desktop reviews.

The rating activity produces performance ratings for each of the specific areas in the 14 SCAs, as given in appendix A. An algorithm is then applied to determine the individual SCA performance rating for each station, resulting in 14 SCA performance ratings for each of the seven Canadian NPPs.

Note: For 2011, all 14 SCAs were used in the calculation of the IPR. (This is a change from the 2010 NPP Report where only 10 out of the 14 SCAs were used). The IPR is calculated by averaging the SCA ratings.

Figure B.1 depicts the methodology to determine the IPR for each NPP station. To simplify the process, only four specific areas are shown.

Figure B.1: Ratings for the 2011 NPP Report


Step 1
Findings from Compliance Program
Step 2
Assess finding for SA1
Assess finding for SA1
Assess finding for SA2
Assess finding for SA2
Assess finding for SA3
Assess finding for SA3
Assess finding for SA4
Assess finding for SA4
Step 3
Rate SA1
Rate SA2
Rate SA3
Rate SA4
Step 4
Rate SCA #1
Rate SCA #2
Step 5
SA = Specific Area
SCA = Safety and Control Area
Integrated Plant Rating (IPR)

Steps shown, from top to bottom, are as follows:

Step 1 - Identify the findings
The findings are identified for each specific area using information from a variety of sources, including inspections, event reviews and desktop reviews. Findings are

evaluated against a set of compliance criteria developed for each specific area that measure the degree of conformity with legal requirements.

Step 2 - Assess findings

CNSC staff evaluate the findings against the compliance criteria and assign one of five possible finding assessments, high, medium, low, negligible or positive. The finding assessment category depends on the degree of negative impact on the effectiveness of the specific area as given in the manner defined in table B.1.

Table B.1: Findings assessment categories

Findings category	**Definition**
High	Major negative impact on effectiveness of safety and control measures in the specific area; evidence of breakdown.
Medium	Significant negative impact on effectiveness of safety and control measures in the specific area.
Low	Small negative impact on effectiveness of safety and control measures in the specific area.
Negligible	Insignificant impact on effectiveness of safety and control measures in the specific area.
Positive	Evidence that the specific area is effective.

Step 3 - Rate the specific area

CNSC staff consider the relevant findings for the specific area and determine the effectiveness using a CNSC-developed guideline. The findings are judged in the context of the performance objective for the relevant SCA. The assessed effectiveness categories for all findings of a specific area are converted into a performance rating of FS, SA, BE, or UA (see table B.2). The performance rating definitions are applied for the rating of the specific areas, SCAs and IPRs.

Table B.2: Performance ratings for specific areas, SCAs and IPRs

Rating category	**Definition**
FS	Safety and control measures were highly effective
SA	Safety and control measures were sufficiently effective
BE	Safety and control measures were marginally ineffective
UA	Safety and control measures were significantly ineffective

Step 4 - Rate the SCA

The specific area ratings are converted to an integer-based value. Individual specific area ratings are then averaged to determine the SCA rating.

Step 5 - Integrated plant rating

The IPR is determined for each station through averaging the values for all 14 SCA ratings for each station.

The industry average SCA and IPR ratings are determined through averaging the seven individual ratings for the stations: Bruce A, Bruce B, Darlington, Pickering A, Pickering B, Gentilly-2 and Point Lepreau.

Appendix C: Research and Development Efforts in Support of NPP Regulation

This appendix provides information on research and development (R&D) activities being conducted by the industry and CNSC to enhance the safety of NPP operations.

C.1 Industry R&D activities

The CANDU owners group (COG) R&D program and the Industry Standard Toolset (IST) program are sponsored by four Canadian utilities (Ontario Power Generation, Bruce Power, NB Power and Hydro-Québec), by the Romanian Societatea Nationala NuclearElectrica, and by Atomic Energy of Canada Limited. As specified in COG-10-9205, *Safety and Licensing R&D Program 2010/2011 Operational Plan* [30], the COG R&D and IST programs were established to support the safe, reliable and efficient operation of CANDU reactors, and are managed under five technical areas:

- fuel channels
- safety and licensing
- health, safety and the environment
- chemistry, materials and components
- IST

The CNSC has reviewed various submissions from the industry on the work plans, analysis methodology and results for these ongoing safety analysis programs or topics.

C.2 CNSC R&D activities

Generic action items

Generic action items (GAIs) refers to those unresolved safety-related issues which, in addition to being applicable to several CANDU plants, have been singled out by CNSC staff as requiring corrective actions to be taken by the licensees, within a reasonable time frame.

Four GAIs were open in 2011 (see table C.1): two of these (00G01 "Channel voiding during a LOCA" and 01G01 "Fuel management and surveillance software upgrade") are expected to close in 2012. The remaining two (95G04 "Positive void reactivity uncertainty – treatment in LLOCA analysis" and 99G02 "Replacement of reactor physics computer codes used in safety analyses of CANDU reactors") will be tracked/monitored under the CANDU safety issues (CSIs) category.

Table C.1: Generic Action Items in 2011

GAI	Title	Brief description	Notes	Expected closure date
95G04	Positive void reactivity uncertainty - treatment in LLOCA analysis	Accuracy of void reactivity calculations is a significant safety issue in the analysis of design-basis accidents involving channel voiding, especially for large LOCAs. Uncertainties and safety margin adequacy are the main questions.	Closed. This item will be tracked under CSIs, as its scope is fully covered by the LLOCA-related CSIs. The closure criteria of the GAI are a subset of the re-categorization criteria of LLOCA CSIs.	Closed in Feb. 2012 (replaced by LLOCA CSIs, see table C.2A)
99G02	Replacement of reactor physics computer codes used in safety analyses of CANDU reactors	Shortcomings need to be rectified, with respect to inaccurate computer code predictions of key parameters for accident conditions, lack of proper validation and a lag of licensees' methods and codes behind the state of knowledge in this area.	Closed. This item will be tracked under CSIs, as its scope is fully covered by the LLOCA-related CSIs. The closure criteria of the GAI are a subset of the re-categorization criteria of LLOCA CSIs.	Closed in Feb. 2012 (replaced by LLOCA CSIs, see table C.2A)
00G01	Channel voiding during a LOCA	At issue is the adequate validations of computer codes used for the prediction of overpower transients during large LOCA for CANDU reactors with a positive coolant void reactivity coefficient.	As the majority of the actions required for closing this GAI have been completed, it is expected to be closed; the residual activities may be tracked/monitored under a site-specific action item.	2012
01G01	Fuel management and surveillance software upgrade	Compliance with reactor physics safety limits–defining the safe operating envelope, such as channel and bundle power limits–has enhanced the need for an improved analytical model, validated over a broader range of applications and conditions, plus better-defined compliance allowances and more consistent procedures.	As the majority of the required actions for closing this GAI have been completed, it is expected to be closed; the residual activities may be tracked/monitored under a site-specific action item.	2012

CANDU safety issues

The issues identified as CSIs should not be viewed as questioning the safety of operating reactors, which have attained a very high operational safety record. Rather, these are areas where uncertainty in knowledge exists, where the safety assessment has been based on conservative assumptions, and where regulatory decisions are required or need to be confirmed. Further work, including experimental research, may be required to more accurately determine the overall effect of an issue on the safe operation of the facility, and to confirm that adequate safety margins exist. Note that some of the safety issues identified for CANDU reactors are common to other reactor types as well.

In 2011, 13 CSIs requiring further experimental and/or analytical studies were pending resolution, as shown in tables C.2A and C.2B. Four of these are related to large loss of coolant accidents (LLOCAs), while the remaining nine belong to the group of non-LLOCA issues.

The resolution of most of these CSIs is expected by 2013.

Table C.2A: Details of the LLOCA CANDU safety issues (CSIs)

CSI	Title	Brief Description	Notes	Target date
AA 9	Analysis for void reactivity coefficient	The LLOCA design-basis event is one of the most difficult accidents to analyze for a CANDU reactor, because many aspects of the reactor behaviour under accident conditions–including fuel and voiding transients, and its computer modeling–are subject to some uncertainties.	The CNSC has developed an interim regulatory position, in case that a study, analytical or plant operation finding, with an adverse impact on LLOCA safety margins, emerges during this period. The interim position is consistent with the risk control measures for CSIs, and will remain in effect until the recommendations of the COG LLOCA working group are accepted by the CNSC and are fully implemented by the industry.	March 2013
PF 9	Fuel behaviour in high temperature transients			
PF 10	Fuel behaviour in power pulse transients			
PF 12	Channel voiding during a large LOCA			

Table C.2B: Details of the non-LLOCA CANDU safety issues (CSIs)

CSI	Title	Brief Description	Notes	Target date
CI 1	Fuel channel integrity and effect on core internals	Safety-related functions in nuclear power plants must remain effective throughout the life of the plant. Licensees are expected to have a program in place, to prevent, detect and correct significant degradation, due to aging, in the effectiveness of important safety-related functions.	Licensees have aging management programs, as well as fitness for service guidelines for life limiting components (i.e., feeders, pressure tubes, steam generator tubes). However, licensee programs for management of aging of other systems and components have not yet been systematically implemented.	December 2012
GL 3	Aging of equipment and structures			December 2012
PF 19	Impact of aging on safe plant operation			December 2012
PF 20	Analysis methodology for neutron/ regional overpower	The neutron/regional overpower trip setpoint function is designed to provide the reactor trip for the analyzed core states prior to fuel dry-out. The trip setpoint	CNSC staff agreed with the conclusions of an independent technical panel, and advised licensees that further development work is	June 2012

CSI	Title	Brief Description	Notes	Target date
		is designed to prevent any potential fuel damage, primarily for slow loss of regulation events.	required on the methodology, before its full utilization for licensing applications.	
SS 5	Hydrogen control measures during accidents	Licensees have committed to installing passive autocatalytic recombiners (PARs) to improve hydrogen control during design-basis accidents.	PARs will be installed at all Canadian NPPs, to provide an additional line of defence to the existing hydrogen mitigation strategies. PARs are installed at Bruce A Units 1 and 2, Darlington Unit 3, Pickering A Unit 4, Gentilly-2 and Point Lepreau. Licensees will provide the planned dates for PARs installation at the remaining units.	June 2012
PSA 3	Design of the balance of plant – steam protection	This issue is applicable to the multi-unit stations. In these stations, steam line breaks and feedwater line breaks are the largest contributors to core damage frequency and large release frequency, accounting for about 70 percent to 80 percent. A high energy line break, such as a steam line break or feed water line break, could lead to widespread damage of many electrical cabinets and systems.	Licensees need to consider practicable measures to reduce the probability of consequential failures of support systems to control, cool, and contain (e.g., instrument air, electrical, heating ventilation air conditioning, emergency forced air discharge system, air cooling units).	March 2014
IH 6	Systematic assessment of high energy line break effects	Dynamic effects at high energy line breaks (e.g., pipe whip, jet impingement) can cause consequential failure of structures, systems and components (SSCs) and impair defence-in-depth. The issue is primarily related to the fact that there has not been a fully documented systematic review of the consequences of high energy line breaks.	The industry has to provide systematic analysis for protecting the structures, systems and components (SSCs) from the effects of postulated pipe rupture.	After 2013

CSI	Title	Brief Description	Notes	Target date
AA 3	Computer code and plant model validation	NPP licensees have established specific validation programs for industry standard computer codes, to provide the necessary confidence in the safety analyses being performed.	Existing code validation work does not, in general, comply with the requirements that would allow a full qualification of these codes.	To be determined
PF 18	Fuel bundle /element behaviour under post dry-out conditions	Lack of rigour/confidence in the specific models, such as, fuel bundle deformation, reduces confidence in the prediction of fuel element or fuel channel failure.	Licensees need to present experimental or analytical evidence to clarify the conditions for fuel deformation and for fuel sheath failure (i.e., dry-out, fuel temperature, timing of failure), and for the consequential failure of fuel channels.	To be determined

Appendix D: 2011 NPP Collective Effective Doses

The following figures provide a five-year trend (from 2007 to 2011) of the annual collective effective doses to workers at each station. This information has been broken down to illustrate the operational state of the reactor when the dose was received (i.e., during operation or during outages/refurbishment), and the pathways of exposure (i.e., internal or external). Note that the figures represent the doses received by the same group of workers.

For each NPP:

- The first figure provides collective effective doses received during routine operations (day-to-day) versus doses received during outages/refurbishment. The collective effective dose shown for routine operations and outages/refurbishment includes both external and internal doses.
- The second figure provides the collective effective doses received from internal and external exposures for all radiological activities performed during the year. This data may indicate strengths or weaknesses in a plant's radiation protection program.

The annual collective dose is the sum of the effective doses received by all the workers at that NPP in a year. It is measured in person-Sievert (p-Sv). There is no regulatory dose limit for the annual collective effective dose; however, it is used internationally as a benchmark for assessing the reactor dose performances.

For routine operations, variations between years are attributed, in part, to how long the plant operated during each year, as well as typical dose rates associated with the operation of the station.

The outage dose (planned and forced) includes the dose to all personnel, including contractors. Parameters affecting the dose include the number of outages for the year, the scope and duration of the work, the number of workers involved, and the dose rates associated with the outage work.

The external dose is the portion of the dose that was received from radiation sources outside the body, while the internal dose is the portion received from radioactive material taken into the body.

In 2011, approximately 87 percent of the collective effective dose was due to outage activities, and most of the radiation dose received by the workers came from external exposure. Approximately 10 percent of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

Note: Caution should be used when comparing the collective effective dose data between NPPs; such a comparison is not entirely appropriate, due to the differences between individual stations (such as design, age, operation and maintenance). A more reliable approach is to focus on year-to-year results at a particular NPP, or to look at the entire industry.

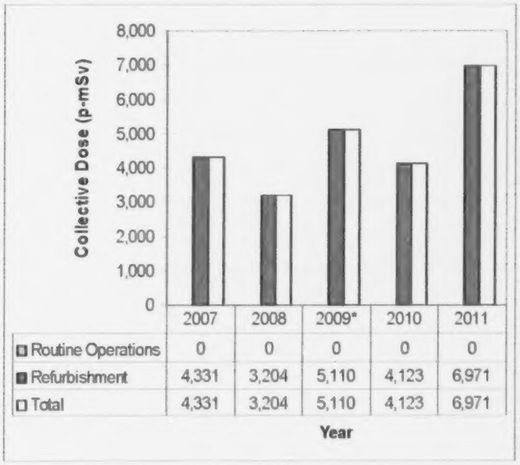
D.1 Annual collective effective doses at Bruce A and B

In 2011, the collective effective doses at Bruce A and B remained above the industry average. At Bruce A, the additional activities to extend the in-service period of Unit 3 represented a significant contributor to the collective effective dose. At Bruce B, variations in the collective effective dose from year to year are due primarily to the number and scope of outages. Bruce Power has established 5-year dose reduction plans, with the objectives of reducing collective effective dose.

In 2011, the annual collective effective doses associated with refurbishment activities were the highest since the initiation of the project, due to the types of radiological activities performed. Feeder replacement and re-tube activities accounted for approximately 63 percent and 11 percent of the total collective effective dose. The refurbishment activities at Bruce A Units 1 and 2 are expected to be completed in 2012, and remain within the estimated project dose of 28.0 p-Sv (28,000 p-mSv).

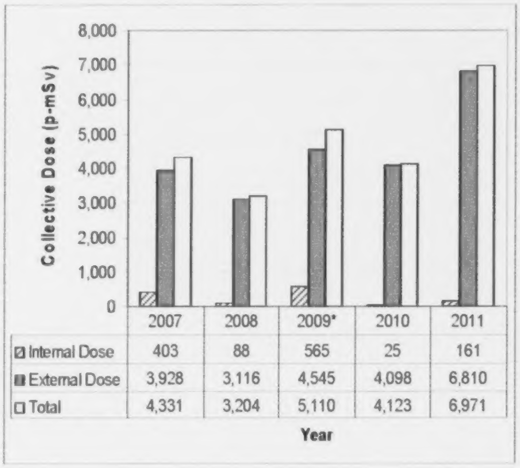
The 2011 annual effective doses to workers are provided in section 1A.7.

Figure D.1: Collective effective dose by operational state for Bruce A – Units 1 and 2



	2007	2008	2009*	2010	2011
□ Routine Operations	0	0	0	0	0
■ Refurbishment	4,331	3,204	5,110	4,123	6,971
□ Total	4,331	3,204	5,110	4,123	6,971

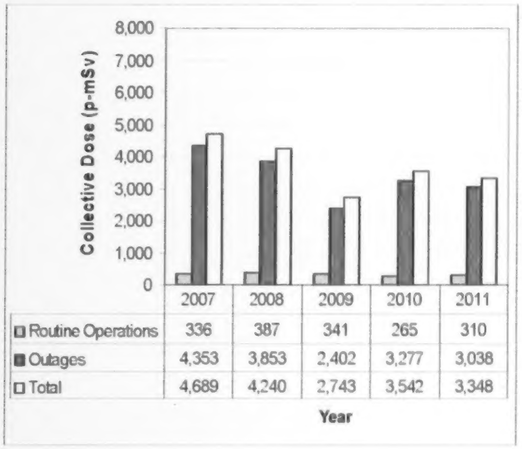
Figure D.2: Internal and external dose for Bruce A – Units 1 and 2



	2007	2008	2009*	2010	2011
▨ Internal Dose	403	88	565	25	161
■ External Dose	3,928	3,116	4,545	4,098	6,810
□ Total	4,331	3,204	5,110	4,123	6,971

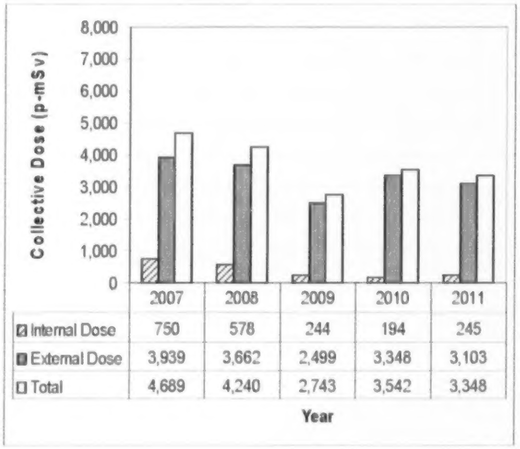
* Includes the total internal dose of 512 mSv to 557 workers involved in the alpha event at Unit 1, in November 2009.

Figure D.3: Collective effective dose by operational state for Bruce A – Units 3 and 4



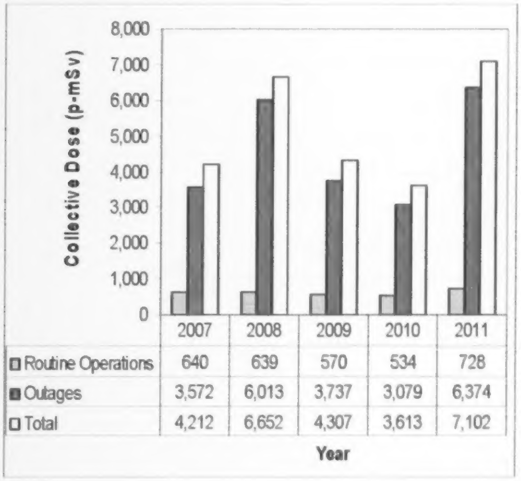
	2007	2008	2009	2010	2011
□ Routine Operations	336	387	341	265	310
■ Outages	4,353	3,853	2,402	3,277	3,038
□ Total	4,689	4,240	2,743	3,542	3,348

Figure D.4: Internal and external dose for Bruce A – Units 3 and 4



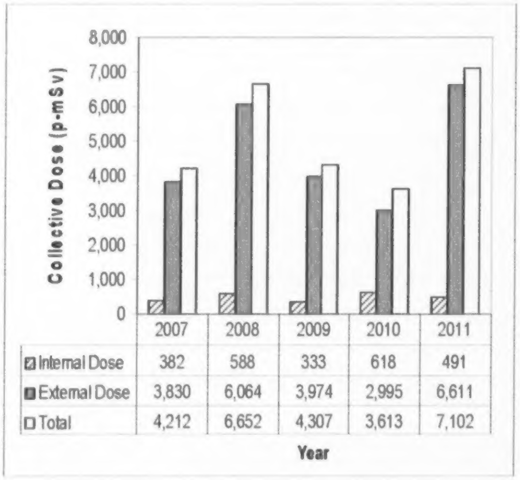
	2007	2008	2009	2010	2011
▨ Internal Dose	750	578	244	194	245
■ External Dose	3,939	3,662	2,499	3,348	3,103
□ Total	4,689	4,240	2,743	3,542	3,348

Figure D.5: Collective effective dose by operational state for Bruce B – Units 5 to 8



	2007	2008	2009	2010	2011
□ Routine Operations	640	639	570	534	728
■ Outages	3,572	6,013	3,737	3,079	6,374
□ Total	4,212	6,652	4,307	3,613	7,102

Figure D.6: Internal and external dose for Bruce B – Units 5 to 8



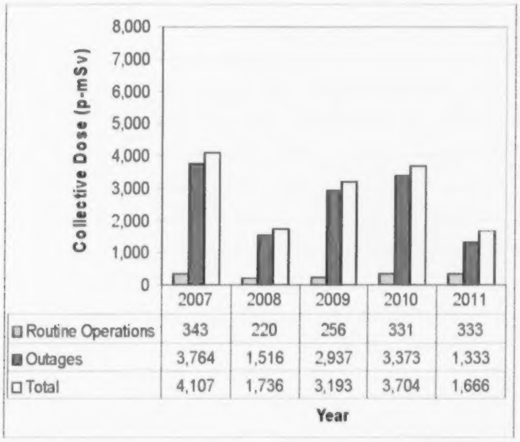
	2007	2008	2009	2010	2011
▨ Internal Dose	382	588	333	618	491
■ External Dose	3,830	6,064	3,974	2,995	6,611
□ Total	4,212	6,652	4,307	3,613	7,102

D.2 Annual collective effective doses at Darlington

In 2011, Darlington was highly effective in controlling worker radiological exposures. Both internal and external doses were the lowest in comparison with previous years. At Darlington, the variations in collective effective dose from year to year are due primarily to the number and scope of outages.

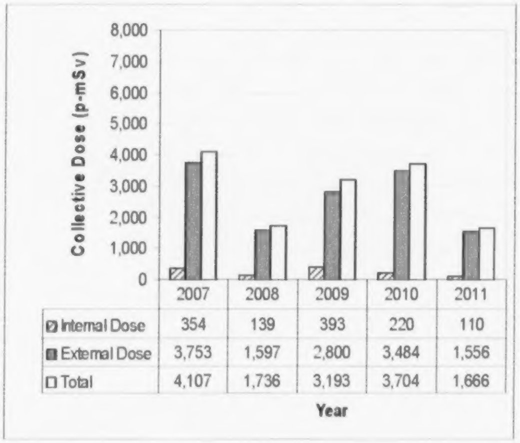
The 2011 annual effective doses to workers are provided in section 1A.7.

Figure D.7: Collective effective dose by operational state for Darlington – Units 1 to 4



	2007	2008	2009	2010	2011
▨ Routine Operations	343	220	256	331	333
■ Outages	3,764	1,516	2,937	3,373	1,333
☐ Total	4,107	1,736	3,193	3,704	1,666

Figure D.8: Internal and external dose for Darlington – Units 1 to 4



	2007	2008	2009	2010	2011
▨ Internal Dose	354	139	393	220	110
■ External Dose	3,753	1,597	2,800	3,484	1,556
☐ Total	4,107	1,736	3,193	3,704	1,666

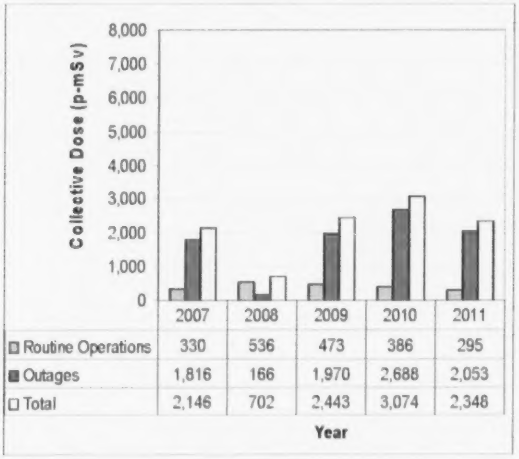
D.3 Annual collective effective doses at Pickering A and B

In 2011, Pickering A and B were effective in controlling worker radiological exposures. Internal and external doses were relatively steady in comparison with previous years. At Pickering A and B, the variations in collective effective dose from year to year were due primarily to the number and scope of outages.

The transition to safe storage of Pickering A Units 2 and 3 was completed in 2010. The dose associated with the radiological activities performed at these units in 2011 was negligible, and they were, therefore, captured under Pickering A Units 1 and 4. Because the transition started in 2008, there are only four years of comparative data available for these units.

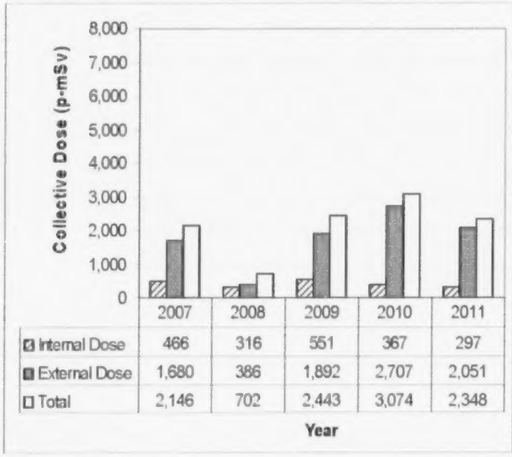
The 2011 annual effective doses to workers are provided in section 1A.7.

Figure D.9: Collective effective dose by operational state for Pickering A – Units 1 and 4



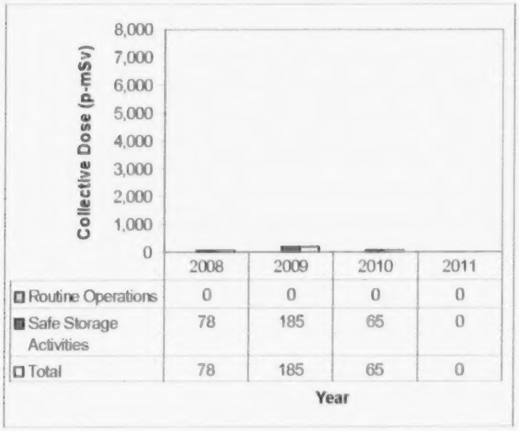
	2007	2008	2009	2010	2011
▢ Routine Operations	330	536	473	386	295
■ Outages	1,816	166	1,970	2,688	2,053
□ Total	2,146	702	2,443	3,074	2,348

Figure D.10: Internal and external dose for Pickering A – Units 1 and 4



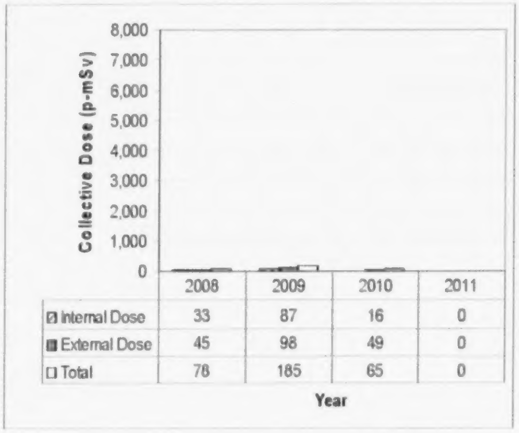
	2007	2008	2009	2010	2011
▨ Internal Dose	466	316	551	367	297
■ External Dose	1,680	386	1,892	2,707	2,051
□ Total	2,146	702	2,443	3,074	2,348

Figure D.11: Collective effective dose by operational state for Pickering A – Units 2 and 3*



	2008	2009	2010	2011
▢ Routine Operations	0	0	0	0
■ Safe Storage Activities	78	185	65	0
□ Total	78	185	65	0

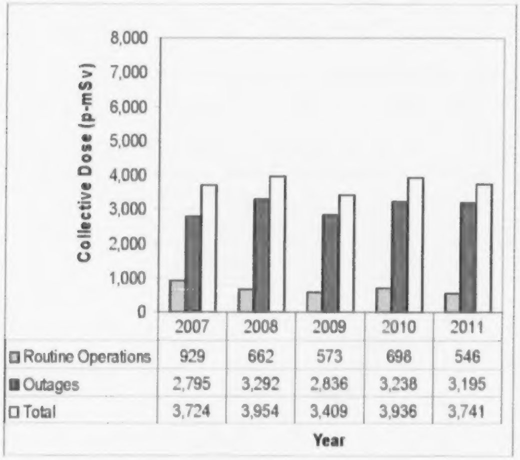
Figure D.12: Internal and external dose for Pickering A – Units 2 and 3*



	2008	2009	2010	2011
▨ Internal Dose	33	87	16	0
■ External Dose	45	98	49	0
□ Total	78	185	65	0

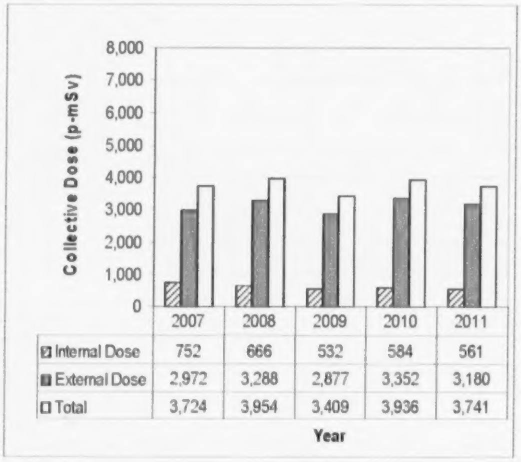
* Transition to safe storage started in 2008 (providing, currently, only four years of comparative data); the associated dose for 2011 is negligible and captured in the graph for Pickering A units 1 and 4

Figure D.13: Collective effective dose by operational state for Pickering B – Units 5 to 8



	2007	2008	2009	2010	2011
▨ Routine Operations	929	662	573	698	546
■ Outages	2,795	3,292	2,836	3,238	3,195
□ Total	3,724	3,954	3,409	3,936	3,741

Figure D.14: Internal and external dose for Pickering B – Units 5 to 8



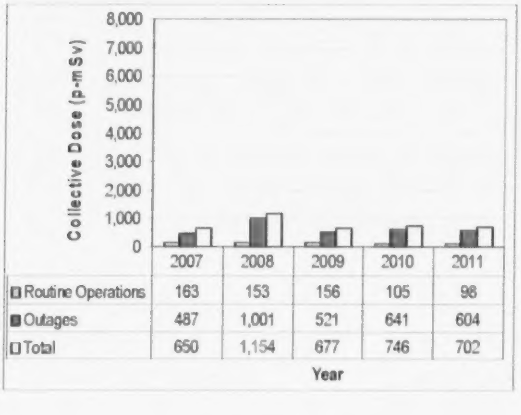
	2007	2008	2009	2010	2011
▨ Internal Dose	752	666	532	584	561
■ External Dose	2,972	3,288	2,877	3,352	3,180
□ Total	3,724	3,954	3,409	3,936	3,741

D.4 Annual collective effective doses at Gentilly-2

In 2011, Gentilly-2 was effective in controlling worker radiological exposures. Internal and external doses were relatively steady in comparison with previous years. At Gentilly-2, the variations in collective effective dose from year to year were due primarily to the number and scope of outages.

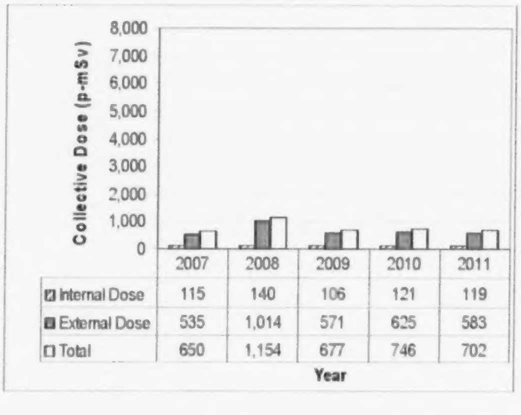
The 2011 annual effective doses to workers are provided in section 1A.7.

Figure D.15: Collective effective dose by operational state for Gentilly-2



	2007	2008	2009	2010	2011
▨ Routine Operations	163	153	156	105	98
■ Outages	487	1,001	521	641	604
□ Total	650	1,154	677	746	702

Figure D.16: Internal and external dose for Gentilly-2



	2007	2008	2009	2010	2011
▨ Internal Dose	115	140	106	121	119
■ External Dose	535	1,014	571	625	583
□ Total	650	1,154	677	746	702

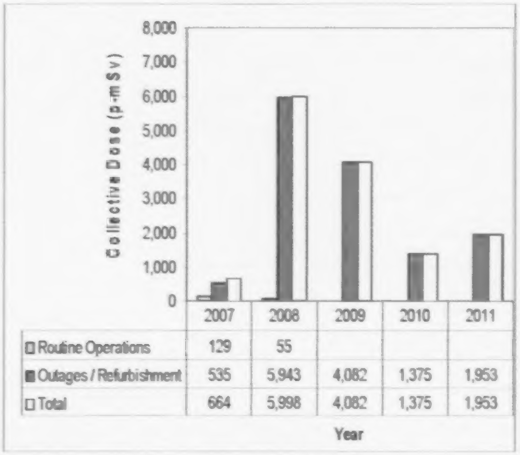
D.5 Annual collective effective doses at Point Lepreau

In 2011, the collective effective doses were slightly higher than the previous year, due to an increase in the number of radiological activities performed, in comparison to 2010. The main contributor to the collective effective dose, in 2011, was the installation of calandria tubes and fuel channels, which accounted for approximately 64 percent and 24 percent of the annual collective effective dose, respectively. Both of these major radiological work activities were completed under the initial dose estimates.

The refurbishment activities at Point Lepreau are expected to be completed in 2012, and within the estimated project dose of 12.7 p-Sv (12,700 p-mSv). At the end of 2011, the total collective effective dose, as measured from the start of the refurbishment project in 2008, was approximately 11.7 p-Sv (11,700 p-mSv).

The 2011 annual effective doses to workers are provided in section 1A.7.

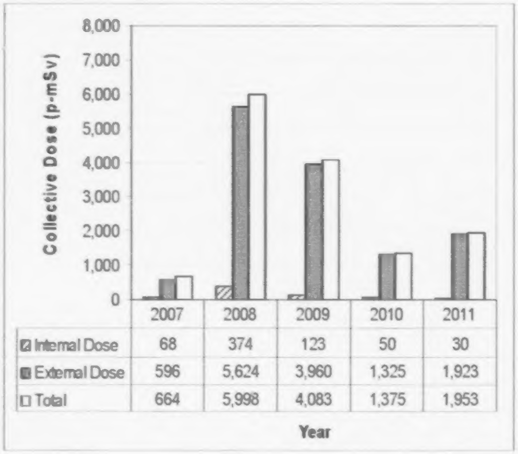
Figure D.17: Collective effective dose by operational state for Point Lepreau



	2007	2008	2009	2010	2011
☐ Routine Operations	129	55			
■ Outages / Refurbishment	535	5,943	4,082	1,375	1,953
☐ Total	664	5,998	4,082	1,375	1,953

Refurbishment began in April 2008

Figure D.18: Internal and external dose for Point Lepreau



	2007	2008	2009	2010	2011
▨ Internal Dose	68	374	123	50	30
■ External Dose	596	5,624	3,960	1,325	1,923
☐ Total	664	5,998	4,083	1,375	1,953

D.6 Average collective effective doses for all Canadian NPPs in operation

In 2011, seventeen reactor units were operational. The total collective effective doses from routine operations and outages at operating Canadian NPPs were relatively steady in comparison with previous years. Therefore, Canada's NPPs have maintained an average annual collective effective dose per reactor unit of approximately 1 p-Sv for the past five years.

Figure D.19: Collective effective dose by operational state for operating Canadian NPPs, from 2007 to 2011

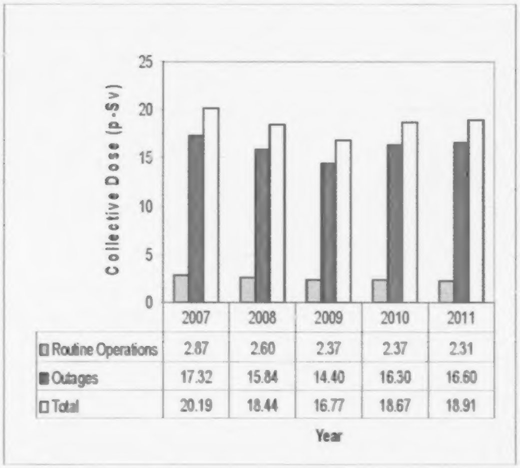
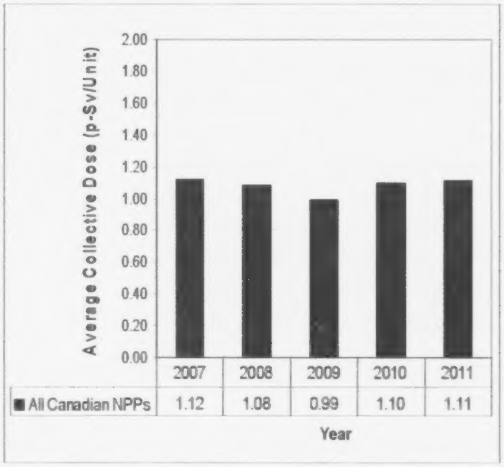


Figure D.20: Average collective effective dose for operating Canadian NPPs, from 2007 to 2011



Refurbishment collective dose from Bruce A (Units 1 and 2) and Point Lepreau are excluded; the safe storage collective dose from Pickering A Units 2 and 3 is also excluded.

Appendix E: Derived Release Limits (DRLs) for Canadian NPPs

For the calculation of radiation doses received by members of the public from routine releases at NPPs, a quantity known as a derived release limit (DRL) is used; this value is based on the regulatory dose limit of 1 milliSievert per year (1 mSv/y).

DRLs are required because nuclear materials released into the environment (through gaseous and liquid effluents from NPPs) can expose members of the public to low radiation doses, via external and internal pathways. External exposure occurs from direct contact with radionuclide-contaminated ground surfaces, or by immersion into contaminated water and air clouds; internal exposure occurs through the intake of radionuclides by inhalation (breathing) and/or intake of contaminated foods. Such radiation doses to members of the public are subject to statutory limits, which are set out in sections 13 and 14 of the *Radiation Protection Regulations*.

Since 1987, DRL calculations have been based on a method recommended by the Canadian Standards Association (CSA) in the standard published as CAN/CSA N288.1-M87 [18]. In 2008, a new revision of this standard was published as CSA-N288.1-08.

The DRLs for gaseous and liquid effluents from Canadian NPPs can be found in tables E.1 and E.2.

Table E.1: DRLs for gaseous effluents

Nuclear power plant	Tritium* (TBq)	Iodine-131 (TBq)	Noble Gases (TBq-MeV**)	Particulates (TBq)	Carbon-14 (TBq)
Bruce A[4]	1.3×10^5	1.2	4.7×10^4	0.31	1.0×10^3
Bruce B[5]	2.7×10^5	0.91	1.1×10^5	0.74	1.1×10^3
Darlington[6]	5.9×10^4 (HTO) 8.5×10^5 (HT)***	1.4	4.5×10^4	0.67	0.35×10^3
Pickering A[7]	5.5×10^4	9.7	2.9×10^4	2.1	6.3×10^3

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[4]. Canadian Nuclear Safety Commission. (November 2009). *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Station A* (PROL 15.00/2014), Appendix C: Derived Release Limits.

[5]. Canadian Nuclear Safety Commission. (November 2009). *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Station B* (PROL 16.00/2014), Appendix C: Derived Release Limits.

[6]. Ontario Power Generation. (October 2011). *Derived Release Limits for Darlington Nuclear Generating Station*, NK38-REP-03482-10001-R01 (as referenced in PROL 13.17/2013).

[7]. Canadian Nuclear Safety Commission. (October 2010). *Nuclear Power Reactor Operating Licence Pickering Nuclear Generating Station A* (PROL 04.01/2013), Appendix A.3: Derived Release Limits.

Nuclear power plant	Tritium* (TBq)	Iodine-131 (TBq)	Noble Gases (TBq-MeV**)	Particulates (TBq)	Carbon-14 (TBq)
Pickering B[8]	5.5 x 10^4	9.7	2.9 x 10^4	2.1	6.3 x 10^3
Gentilly-2[9]	4.4 x 10^5	1.3	1.7 x 10^5	1.9	8.8 x 10^2
Point Lepreau[10]	4.3 x 10^5	10	7.3 x 10^4	5.4	3.3 x 10^3

* Tritium oxide (HTO)

** TeraBecquerel-million electron volts

*** For elemental tritium (HT) resulting from operations at the tritium removal facility at the Darlington Nuclear Generating Station

Table E.2: DRLs for liquid effluents

Nuclear power plant	Tritium* (TBq)	Gross Beta-Gamma Activity (TBq)	Carbon-14 (TBq)
Bruce A[4]	2.1 x 10^6	1.0 x 10^2	2.6 x 10^3
Bruce B[5]	2.3 x 10^6	1.1 x 10^2	2.8 x 10^3
Darlington[6]	5.3 x 10^6	7.1 x 10^1	9.7 x 10^2
Pickering A[7]	5.1 x 10^5	4.7	6.4 x 10^1
Pickering B[8]	5.1 x 10^5	4.7	6.4 x 10^1
Gentilly-2[9]	1.2 x 10^6	5.3	1.0 x 10^2
Point Lepreau[10]	1.6 x 10^7	1.5 x 10^1	3.0 x 10^2

* Tritium oxide (HTO)

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[8]. Ontario Power Generation. (April 2006). *Derived Release Limits for Pickering Nuclear Generating Station B*, NK30-REP-03482-00001-R001 (as referenced in PROL 08.04/2013).

[9]. Hydro-Québec. (2003). *Limites opérationnelles dérivées pour les rejets aériens de Gentilly-2* (as referenced in PERP 10.04/2010).

[10]. New Brunswick Power Nuclear Corporation. (1996). Point Lepreau Generating Station Reference Document: *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*, RD-01364-L1, Revision 2 (as referenced in PROL 17.08/2011).

Appendix F: Status of Action Items Applicable to NPPs

Table F.1 describes those action items (AIs) that apply to each station and the status of each, whether "open" or "closed". Certain NPP AIs depend on the outcome of others and these are indicated as "to be determined" (tbd). Each NPP AI will only be closed once all the stations have produced the required deliverable and it has been accepted by the CNSC. In some cases, station-specific action items may then be opened to track the performance of further deliverables. The table gives the "target completion date" (tcd) as of March 2012.

A complete description of the NPP AIs given in this appendix can be found in the *CNSC Action Plan* [22].

Table F.1: Status of action items applicable to nuclear power plants (as of May 31, 2012)

Ser	Action item	Darlington	Pickering A	Pickering B	Bruce A	Bruce B	Gentilly 2	Point Lepreau
Recommendation 1 – Verify robustness of NPP designs								
1	**AI 1.1.1** An updated evaluation of the capability of bleed condenser / degasser condenser relief valves providing additional evidence that the valves have sufficient capacity. December 2012.	Open tcd 04/12	Open tcd 04/12	Open tcd 04/12	Open	Open	Open	Open
2	**AI 1.1.2** If required, a plan and schedule either for confirmatory testing of installation or provision for additional relief capacity. December 2012.	tbd	tbd	tbd	tbd	tbd	tbd	tbd
3	**AI 1.2.1** An assessment of the capability of shield tank / calandria vault relief. December 2013.	Closed	N/A	Open tcd 06/12	Open	Open	Closed (subject to acceptance)	Closed
4	**AI 1.2.2** If relief capacity is inadequate, an assessment of the benefit available from adequate relief capacity and the practicability of providing additional relief. December 2013.	Closed	N/A	tbd	tbd	tbd	Closed (subject to acceptance)	N/A
5	**AI 1.2.3** If additional relief is beneficial and practicable, a plan and schedule for provision of additional relief. December 2013.	Open	N/A	tbd	tbd	tbd	Open tcd Restart	N/A
6	**AI 1.3.1** Assessments of adequacy of the existing means to protect containment integrity and prevent uncontrolled release in beyond-design-basis accidents including severe accidents. December 2015.	Closed	Open tcd Q4/13	Open tcd Q4/12	Open tcd 06/12	Open tcd 06/12	Closed (subject to acceptance)	N/A

Ser	Action item	Darlington	Pickering A	Pickering B	Bruce A	Bruce B	Gentilly 2	Point Lepreau
7	**AI 1.3.2** Where the existing means to protect containment integrity and prevent uncontrolled releases of radioactive products in beyond-design-basis accidents including severe accidents are found inadequate, a plan and schedule for design enhancements to control long-term radiological releases and, to the extent practicable, unfiltered releases. December 2015.	Open tcd 2015	Open tcd Q4/14	Open tcd Q4/14	Open tcd 12/13	Open tcd 12/13	Open tcd Restart	N/A
8	**AI 1.4.1** A plan and schedule for the installation of passive autocatalytic recombiners as quickly as possible. December 2012.	Closed	Closed	Closed	Open tcd 03/12	Open tcd 02/12	Closed	Closed
9	**AI 1.5.1** An evaluation of the potential for hydrogen generation in the irradiated fuel bay (IFB) area and the need for hydrogen mitigation. December 2013.	Open tcd Q4/12	Open tcd Q4/13	Open tcd Q4/12	Open	Open	Open	Open
10	**AI 1.6.1** An evaluation of the structural response of the IFB structure to temperatures in excess of the design temperature, including an assessment of the maximum credible leak rate following any predicted structural damage. December 2013.	Closed	Open tcd Q1/13	Open tcd Q4/12	Open tcd 12/13	Open tcd 12/13	Open tcd 12/13	Open
11	**AI 1.6.2** A plan and schedule for deployment of any additional mitigating measures shown to be necessary by the evaluation of structural integrity. December 2013.	N/A	tbd	tbd	tbd	tbd	tbd	tbd
12	**AI 1.7.1** A plan and schedule for optimizing existing provisions (to	Open tcd Q1/13	Open tcd Q1/13	Open tcd Q1/13	Open tcd 12/13	Open tcd 12/13	Open tcd 12/13	Open

Ser	Action item	Darlington	Pickering A	Pickering B	Bruce A	Bruce B	Gentilly 2	Point Lepreau
	provide coolant makeup to the primary heat transport system, steam generators, moderator, etc.) and putting in place additional coolant makeup provisions, and supporting analyses. December 2013.							
13	**AI 1.8.1** A detailed plan and schedule for performing assessments of equipment survivability, and a plan and schedule for equipment upgrade where appropriate based on the assessment. December 2013.	Open tcd 12/13	Open tcd 12/13	Open tcd 12/13	Open tcd 12/13	Open tcd 12/13	Open tcd Restart	Open tcd 12/13
14	**AI 1.9.1** An evaluation of the habitability of control facilities under conditions arising from beyond-design-basis and severe accidents. Where applicable, a detailed plan and schedule for control facilities upgrades. December 2014.	Open tcd Q4/12	Open tcd Q4/13	Open tcd Q4/13	Open tcd 12/14	Open tcd 12/14	Open tcd 12/14	Open
15	**AI 1.10.1** An evaluation of the requirements and capabilities for electrical power for key instrumentation and control. The evaluation should identify practicable upgrades that would extend the availability of key instrumentation and control, if needed. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12
16	**AI 1.10.2** A plan and schedule for the deployment of identified upgrades. A target of 8 hours without the need for offsite support should be used. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12
17	**AI 1.11.1** A plan and schedule for	Closed	Closed	Closed	Open	Open	Open	Open

Ser	Action item	Darlington	Pickering A	Pickering B	Bruce A	Bruce B	Gentilly 2	Point Lepreau
	procurement (of emergency equipment and other resources that could be stored offsite). December 2012.	(subject to acceptance)	(subject to acceptance)	(subject to acceptance)	tcd Q4/12	tcd Q4/12	tcd Q4/12	tcd Q4/12
Recommendation 2 – Assessment of site-specific external hazards								
18	**AI 2.1.1** Re-evaluation, using modern calculations and state-of-the-art methods, of the site-specific magnitudes of each external event to which the plant may be susceptible. December 2013.	Closed	Open tcd Q4/13	Open tcd Q4/12	Open tcd 09/12	Open tcd 09/12	Closed (subject to acceptance)	Closed
19	**AI 2.1.2** Evaluation to find out if the current site-specific design protection for each external event assessed in 1 above is sufficient. If gaps are identified a corrective plan should be proposed. December 2013.	Closed	Open tcd Q4/13	Open tcd Q4/12	Open	Open	Closed (subject to acceptance)	Open tcd 12/13
20	**AI 2.2.1** Site-specific implementation plans for RD-310, *Safety Analysis for Nuclear Power Plants*. December 2013.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open	Open	Open	Open tcd 12/13
Recommendation 3 – Enhance modelling capabilities								
21	**AI 3.1.1** Where SAM guidelines have not been developed/finalized or fully implemented, provision of plans and schedules for completion. December 2013.	Closed (subject to acceptance)	Closed (subject to acceptance)	Closed (subject to acceptance)	Closed (subject to acceptance)	Closed (subject to acceptance)	Open	Closed
22	**AI 3.1.2** For multi-unit stations, provision of plans and schedules for the inclusion of multi-unit events in SAM guidelines. December 2013.	Open tcd Q4/13	Open tcd Q4/13	Open tcd Q4/13	Open tcd 12/13	Open tcd 12/13	N/A	N/A
23	**AI 3.1.3** For all stations, provision of plans and schedules for the inclusion of IFB events in station operating documentation where appropriate.	Open tcd 04/12	Open tcd 04/12	Open tcd 04/12	Open tcd 12/13	Open tcd 12/13	Open tcd restart	Closed

Ser	Action item	Darlington	Pickering A	Pickering B	Bruce A	Bruce B	Gentilly 2	Point Lepreau
	December 2013.							
24	**AI 3.1.4** Demonstration of effectiveness of SAM guidelines via table-top exercise and drills. December 2013.	Open tcd Q4/13	Open tcd Q4/13	Open tcd Q4/13	Open tcd 12/13	Open tcd 12/13	Open tcd restart	Closed
25	**AI 3.2.1** An evaluation of the adequacy of existing modelling of severe accidents in multi-unit stations. The evaluation should provide a functional specification of any necessary improved models. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	N/A	N/A
26	**AI 3.2.2** A plan and schedule for the development of improved modelling, including any necessary experimental support. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	N/A	N/A
Recommendation 4 – Assess emergency plans (onsite)								
27	**AI 4.1.1** An evaluation of the adequacy of existing emergency plans and programs. December 2012.	Open tcd 04/12	Open tcd 04/12	Open tcd 04/12	Open tcd 09/12	Open tcd 09/12	Open tcd 12/12	Open tcd 12/12
28	**AI 4.1.2** A plan and schedule to address any gaps identified in the evaluation. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd 03/13	Open tcd 03/13	Open tcd 12/12	Open tcd 12/12
29	**AI 4.2.1** A plan and schedule for the development of improved exercise program. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd 10/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12
Recommendation 5 – Update emergency facilities and equipment								
30	**AI 5.1.1** An evaluation of the adequacy of backup power for emergency facilities and equipment. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd 10/12	Open tcd 10/12	Open tcd 12/12	Open
31	**AI 5.1.2** A plan and schedule to address any gaps identified. December 2012.	Open tcd Q4/12	Open tcd Q4/12	Open tcd Q4/12	Open tcd 12/12	Open tcd 12/12	Open tcd 12/12	Open tcd 06/12

Ser	Action item	Darlington	Pickering A	Pickering B	Bruce A	Bruce B	Gentilly 2	Point Lepreau
32	**AI 5.2.1** Identification of the external support and resources that may be required during an emergency. December 2012.	Open tcd 04/12	Open tcd 04/12	Open tcd 04/12	Open tcd 12/12	Open tcd 12/12	Open tcd 12/12	N/A
33	**AI 5.2.2** Identification of the external support and resource agreements that have been formalized and documented. December 2012.	Open tcd 04/12	Open tcd 04/12	Open tcd 04/12	Open tcd 12/12	Open tcd 12/12	Open tcd 12/12	N/A
34	**AI 5.2.3** Confirmation on whether any undocumented arrangements can be formalized. December 2012.	Open tcd 04/12	Open tcd 04/12	Open tcd 04/12	tbd	tbd	Open tcd 12/12	N/A
35	**AI 5.3.1** Provision of a project plan and installation schedule. December 2012.	Open tcd Q2/12	Open tcd Q2/12	Open tcd Q2/12	Open tcd 12/12	Open tcd 12/12	Open tcd 12/12	Open
36	**AI 5.4.1** Development of source term and dose modelling tools specific to each NPP. December 2012.	N/A	N/A	N/A	N/A	N/A	Open tcd Restart	Open

Acronyms and Abbreviations

AECL	Atomic Energy of Canada Limited
AF	accident frequency
AI	action item
AIM	abnormal incident manual
ALARA	as low as reasonably achievable
AMP	aging management program
ASR	accident severity rate
BDBA	beyond-design-basis accident
BOP	balance-of-plant
BWR	boiling-water reactor
CANDU	Canada Deuterium-Uranium
CANPAC	CANDU Procurement Audit Committee
CATT	Canadian Adversary Testing Team
CEA	Canadian Electricity Association
CEAA	*Canadian Environmental Assessment Act*
CEDA	Canadian Engineering Development Association
CFAM	corporate functional area manager
CM	configuration management
CMD	Commission member document
CNSC	Canadian Nuclear Safety Commission
C of A	Certificate of Approval
COG	CANDU Owners Group
COP	continued operations plan
CRSS	control room shift supervisor
CSA	Canadian Standards Association
CSI	CANDU safety issue
CVC	compliance verification criteria
DBA	design-basis accident
DBT	design-basis threat
DERAD	Défense Radiologique
DRL	derived release limit
DVC	document version control
EA	environmental assessment
EAC	external advisory committee
EAP	environmental assessment program
EC	Environment Canada
EDS	electrical distribution system
EFPH	effective full power hours
ENR	early notification report
EOC	Emergency Operations Centre
EPRI	Electric Power Research Institute
EPS	emergency power supply
EQ	environmental qualification
ERT	emergency response team

FFD	fitness for duty
FFSGs	fitness for service guidelines
FRP	fibre-reinforced plastic
GAI	generic action item
GAR	global assessment report
GNSCR	*General Nuclear Safety and Control Regulations*
GSS	guaranteed shutdown state
HF	human factors
HTS	heat transport system
I&C	instrumentation and control
IAEA	International Atomic Energy Agency
IFB	irradiated fuel bay
IIP	integrated implementation plan
IPR	integrated plant rating
IRRS	Integrated Regulatory Review Service
ISR	integrated safety review
IST	industry standard toolset
LCAC	large commercial aircraft crash
LCH	licence conditions handbook
LCMP	lifecycle management plan
LLOCA	large loss of coolant accident
LOCA	loss of coolant accident
LOECI	loss of emergency coolant injection
LTA	lost-time accident
MOU	memorandum of understanding
MSC	minimum shift complement
MSM	Management System Manual
NB Power	New Brunswick Power
NGS	nuclear generating station
NOP	neutron overpower protection
NPP	nuclear power plant
NPT	*Non-Proliferation Treaty*
NSCA	*Nuclear Safety and Control Act*
NUPIC	Nuclear Procurement Issues Committee
OPEX	operating experience
OPG	Ontario Power Generation
OP&Ps	operating policies and principles
P&G	principles and guidelines
PARs	passive autocatalytic recombiners
PHT	primary heat transport
PHTS	primary heat transport system
PI	performance indicator
PIE	post-irradiation examination
PIP	periodic inspection program
PIV	physical inventory verification
PLR	Point Lepreau refurbishment

PMCR	preventive maintenance completion ratio
PNERP	Provincial Nuclear Emergency Response Plan
PRA	probabilistic risk assessment
PROL	power reactor operating licence
PSA	probabilistic safety assessment
PSR	periodic safety review
PSS	plant shift supervisor
PTNSR	*Packaging and Transport of Nuclear Substances Regulations*
PTP	Performance Testing Program
QA	quality assurance
R&D	research and development
RBSW	reactor building service water
RHP	responsible health physicist
RO	reactor operator
SAI	safety analysis improvement
SAT	systematic approach to training
SAM	severe accident management
SCA	safety and control area
SDS	shutdown system
SFRs	safety factor reports
SG	steam generator
SHP	senior health physicist
SOE	safe operating envelope
SON	Saugeen Ojibway Nations
SOP	sustainable operations plan
SRWMF	Solid Radioactive Waste Management Facility
SSCs	structures, systems and components
SWS	service water systems
tbd	to be determined
tcd	target completion date
TDGR	*Transportation of Dangerous Goods Regulations*
TEPCO	Tokyo Electric Power Company
TRF	tritium removal facility
U0O	Unit 0 operator
UCLF	unplanned capability loss factor
WANO	World Association of Nuclear Operators
WG	working group
WSP	west-shift-plus

Glossary

beyond-design-basis accident (BDBA)
Accident conditions less frequent and more severe than a design-basis accident. A BDBA may or may not involve core degradation.

calandria tubes
Tubes that span the calandria and separate the pressure tubes from the moderator. Each calandria tube contains one pressure tube.

Commission/Commission Tribunal
The Canadian Nuclear Safety Commission established by section 8 of the *Nuclear Safety and Control Act* (NSCA). Often referred to as the Commission Tribunal to distinguish it from the CNSC as a whole, it is a corporate body of not more than seven members, appointed by the Governor in Council, to perform the following functions:

- regulate the development, production and use of nuclear energy and the production, possession, use and transport of nuclear substances
- regulate the production, possession and use of prescribed equipment and prescribed information
- implement measures respecting international control of the development, production, transport and use of nuclear energy and nuclear substances, including those respecting the non-proliferation of nuclear weapons and nuclear explosive devices
- disseminate scientific, technical and regulatory information concerning the activities of the CNSC and the effects on the environment and on the health and safety of persons, of the development, production, possession, transport and uses referred to above

Commission member document (CMD)
A document prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors. Each CMD is assigned a specific identification number.

derived release limit (DRL)
A limit imposed by the CNSC on the release of a radioactive substance from a licensed nuclear facility, such that compliance with the derived release limit gives reasonable assurance that the regulatory dose limit is not exceeded.

design-basis accident (DBA)
Accident conditions against which a nuclear power plant is designed according to established design criteria, and for which the damage to the fuel and the release of radioactive material are kept within authorized limits.

design life
The period specified for the safe operation of the facility, systems, structures and components.

effective full power hour (EFPH)
The period over which a component sees service that equals the amount of full service the component would have experienced if it was operated continuously over a full hour.

feeder
There are several hundred channels in the reactor that contain fuel. The feeders are pipes attached to each end of the channels used to circulate heavy water coolant from the fuel channels to the steam generators.

guaranteed shutdown state (GSS)
A method for ensuring that a reactor is shut down. The GSS includes adding a substance to the reactor moderator, which absorbs neutrons and removes them from the fission chain reaction, or draining the moderator from the reactor.

International Atomic Energy Agency (IAEA)
An independent international organization related to the United Nations system. The IAEA, located in Vienna, works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The IAEA reports annually to the UN General Assembly and, when appropriate, to the Security Council regarding non-compliance by states with respect to their safeguards obligations, as well as on matters relating to international peace and security.

minimum shift complement
The minimum number of qualified workers who must be present at all times to ensure the safe operation of the nuclear facility and to ensure adequate emergency response capability. Also referred to as "minimum staff complement".

pressure tubes
Tubes that pass through the calandria and contain 12 or 13 fuel bundles. Pressurized heavy water flows through the tubes, cooling the fuel.

probabilistic safety assessment (PSA)
A comprehensive and integrated assessment of the safety of the reactor facility. The safety assessment considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of the safety of the reactor facility, as follows:

- a Level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures
- a Level 2 PSA starts from the Level 1 results and analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment

- a Level 3 PSA starts from the Level 2 results and analyzes the distribution of radionuclides in the environment and evaluates the resulting effect on public health

risk
The chance of injury or loss, defined as a measure of the probability and severity of an adverse effect (consequences) to health, property, the environment or other things of value; mathematically, it is the probability of occurrence (likelihood) of an event multiplied by its magnitude (severity).

risk-informed approach
A modern approach to the classification of accidents, one that considers a full spectrum of possible events, including the events of greatest consequence to the public.

root-cause analysis
An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event, which is conducted with a level of effort consistent with the safety significance of the event.

safety-related system
As defined in the Canadian Standards Association publication CSA-N285.0-08, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants*, and that is referenced in the nuclear power plant licence, “those systems and their related components and supports that, by failing to perform in accordance with the design intent, have the potential to impact the radiological safety of the public or nuclear power plant personnel. Those systems and their components involve

- “the regulation (including controlled startup and shutdown) and cooling of the reactor core under normal conditions (including all normal operating and shutdown conditions)
- “the regulation, shutdown, and cooling of the reactor core under anticipated transient conditions, accident conditions, and the maintenance of the reactor core in a safe shutdown state for an extended period following such conditions
- “limiting the release of radioactive material and the exposure of plant personnel and/or the public to meet the criteria established by the regulatory authority with respect to radiation exposure during and following normal, anticipated transient and accident conditions

“Notes:

(1) “The term ‘safety-related system’ covers a broad range of systems, from those having very important safety functions to those with a less direct effect on safety. The larger the potential radiological safety effect due to system failure, the stronger the ‘safety-related’ connotation.

(2) “ ‘Safety-related’ ” also applies to certain activities associated with the design, manufacture, construction, commissioning, and operation of safety-related systems and to other activities that can similarly affect the radiological safety of the public or plant personnel, such as environmental and effluent monitoring, radiation protection and dosimetry, and radioactive material handling (including

waste management). The larger the potential radiological safety effect associated with the performance of the activity, the stronger the 'safety-related' connotation.

(3) "Certain failures of other systems can adversely affect a safety-related system (e.g., through flooding or mechanical damage)."

safety report
A report, as described in regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants,* that provides descriptions of the structures, systems and components of a facility, including their design and operating conditions. This includes a final safety analysis report demonstrating the adequacy of the design of the nuclear facility.

safety system
A system provided to ensure the safe shutdown of the reactor or the residual heat removal from the core, or to limit the consequences of anticipated operational occurrences and design-basis accidents.

serious process failure
A failure of a process structure, system or component:

- that leads to a systematic fuel failure or a significant release from the nuclear power plant, or
- that could lead to a systematic fuel failure or a significant release in the absence of action by any special safety system

setback
A system designed to automatically reduce reactor power at a slow rate if a problem occurs. The setback system is part of the reactor-regulating system. See also "stepback".

special safety system
The shutdown system #1, the shutdown system #2, the containment system, or the emergency core cooling system of a nuclear power plant.

steam generator
A heat exchanger that transfers heat from the heavy water coolant to ordinary water. The ordinary water boils, producing steam to drive the turbine. The steam generator tubes separate the reactor coolant from the rest of the power-generating system.

stepback
A system designed to automatically reduce reactor power at a fast rate if a problem occurs. The stepback system is part of the reactor-regulating system. See also "setback".

structures, systems and components (SSCs)
A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety, except human factors. Structures are the passive elements: buildings, vessels, shielding, etc. A system comprises several components, assembled in such a way as to perform a specific (active) function. A component is a

discrete element of a system. Examples are wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks, and valves.

systematic approach to training (SAT)
A logical progression from identification of the qualifications and competencies required for performing a job, to the design, development, implementation, and maintenance of the training programs, and to the subsequent evaluation and continuous improvement of these training programs. SAT comprises five phases: analysis, design, development, implementation, and evaluation.

systems important to safety
Structures, systems and components of the NPP associated with the initiation, prevention, detection or mitigation of any failure sequence that have the most significant impact in reducing the possibility of damage to fuel, associated release of radionuclides, or both.

Type I inspection
All verification activities related to onsite audits and evaluations of a licensee's programs, processes and practices.

Type II inspection
All verification activities related to routine (item by item) checks and rounds. An equipment or system inspection or operating practice assessment carried out by CNSC staff, which includes item-by-item checks and rounds that focus on outputs or performance of licensee programs, processes and practices. Findings play a key role in identifying where a Type I inspection may be required to determine systemic problems in programs, processes or practices.

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